European Strategy Forum on Research Infrastructures
Innovation Working Group

Innovation-oriented cooperation of Research Infrastructures

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Foreword

The third volume of the ESFRI Scripta series is built on the outcomes of the *ad hoc* Working Group on Innovation as approved by the Forum in March 2016, and additional revisions and update that were completed in December 2017.

The Innovation Working Group was created by ESFRI in 2013 to address the impact of Research Infrastructures on innovation. In 2015 it was mandated to report to the Forum on how industrial R&D exploits the rich knowledge environment of Research Infrastructures, how the scientific results of RIs percolate into innovation value, how the industry benefits from access to RIs and to scientific data.

The urge of innovative practices and products by industry and civil services need to encounter the solid new knowledge and scientific outlook that are carried out at Research Infrastructures in an increasingly effective way. There is room for optimizing the link between scientific new knowledge and innovation, but the bridge has been built understanding that the path from curiosity-driven research to the exploitation of results for short-term economic value is "non-linear" in the language of physicists, implying that a variety of knowledge transfer and collaboration channels do exist between research and industry, and some or other can prevail at different times in determining innovation.

This ESFRI Scripta volume describes the different forms of industry and Research Infrastructure collaboration that generate innovation: industry as supplier for the construction / upgrade of the RIs, being instructed and guided in developing new technologies or production protocols; industry as partner of RIs and industry as user exploiting the specific dedicated access modes as well as through the academic access supported by research grants.

The open innovation model does include Research Infrastructures at the supply side of new knowledge and also as effective testbeds of innovative devices that can be benchmarked against mature technologies in performing research. Detectors of particles, X-rays, neutrons, and their associated ultrafast, low noise electronics are developed first and qualified later by their adoption by RI for advanced research, yielding very direct innovation in all field of applications in medical, environmental, information, production monitoring. Reference signal sources, from light emission devices to precision clocks, are again developed and qualified by adoption at RIs. In the bio-medical sector RIs make available samples, images, protocols that continuously enrich the knowledge basis for open innovation to flourish. In the broad-band communication of data and high power / high throughput computing, as well as in environmental observation and modelling, or in societal studies, the RIs provide again the most advanced testbeds for innovation.

Updates statistics of the easily measureable facts, like usage by industry of analytical or healt&food RIs, show a larger and larger impact of RIs on innovation activities. Key aspects of the link between research infrastructure and innovation are also the training of scientists and research engineers and their mobility to and from basic science at the RI and innovation in the society.

The growth of large hubs of science and innovation around large scale RIs are one of the effective models of open innovation, attracting economic activities and generating value.

In fact all the enabling technologies for the Industry 4.0 “smart factory” paradigm are at work, or have been pioneered, at RIs – ranging from simulation, horizontal and vertical integration, cloud computing, remote access to facilities, to big data analytics and advanced additive manufacturing, and can serve as reference or implementations or tests.

A great impact on innovation is expected from the openness of well-documented high-quality research data supported by reliable and effective data services. This is already happening to some degree and much is expected from open-science systems like those already in place at many ESFRI Landmarks and Projects as well as at other Research Infrastructures and all those to be promoted and federated in the EOSC. Metrology is a key issue for the translation of basic research results to innovation-ready information. It is again in the remit of RIs to provide calibrated data to users as well as to run advanced calibrations of innovative devices at least at prototype level.

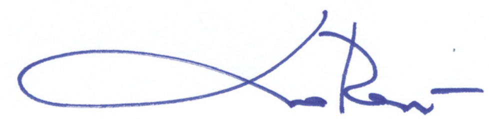
Hopefully this volume of ESFRI Scripta will be a useful reference for framing the optimal support actions for a more and more effective translation of scientific knowledge into innovation, exploiting fully the great potential of Research Infrastructures, and adding relevant aspects to their strategy of long term valorisation.

I wish to thank the Innovation Working Group and its Chair, Dr. Jean Moulin, for updating this report, and for the continuous action of elaboration of the innovation impact of RIs. I wish to thank also the ESFRI Forum for supporting this publication, and the technical editors Maddalena Donzelli, Marina Carpineti and Petra dell’Arme for their work.

Milan, January 2018

Giorgio Rossi

Chair of ESFRI



Contents

Executive summary

This report was presented to ESFRI in March 2016 for final approving according to the mandate which was given in 2013 – and extended in June 2015 – to the Working Group on Innovation and following the conclusions of the discussion of the interim report presented at the 53rd Forum Meeting held on 12th June 2015 in Lisbon. It is focused on the main objectives which were defined by the Forum – see the Terms of Reference of the Working Group on Innovation – INNO WG – namely to contribute to the development of a strategy aimed to strengthen and improve the relations between Research Infrastructures and Industry and to promote the potential for innovation of Research Infrastructures in all its aspects. All sections of the report are concentrated on these issues. Examples of good practices are given in the **Boxes**. A set of conclusions and recommendations has been drawn to the attention of Research Infrastructures managers and ESFRI in the perspective of the further implementation of the ESFRI Roadmap. The group held 8 meetings in which representatives of the various categories of stakeholders were successively invited to participate and to present their experiences, needs and expectations.

Introduction

The Working Group on Innovation (INNO WG) was set-up in 2013 in order "to propose to the Forum the broad lines of a strategic plan for an industry-oriented cooperation" of the Research Infrastructures (RIs), as detailed in the Terms of Reference in the **Appendices**. The results of its work was intended to contribute to the implementation of the ESFRI's Strategy, the Roadmap 2016 and successive updates.

The objectives that have been recognised by the Forum can be summarized as follows:

- to identify and promote the innovation and industrial capabilities of the RIs on the ESFRI Roadmap;
- to strengthen the cooperation of pan-European RIs with industry, in particular during the construction phase;
- to promote the access of industrial users to the RIs.

Among the main tasks that have been undertaken by INNO WG, the following two were particularly emphasized:

- to propose solutions to the various problems concerning RI-Industry interactions, especially with industrial suppliers;
- to explore the major obstacles for enterprises to use publicly owned RIs, and to identify the specific requirements for hosting industry users.

The INNO WG has put a "bi-directional" focus in all its activities on the improvement of the mutual cooperation between RIs and industry. In this properly balanced and "win-win" approach a central need is identified, the need to increase and optimize simultaneously the added-value provided by RIs to industry and the contribution of industry to the development of RIs. The Group considers that the implementation of simultaneous actions on these two complementary axes will reinforce their global potential impact.

This implies to pay particular attention to:

1. the place and role of the RIs in the innovation chain, especially within innovation ecosystems and in relation to Grand Societal Challenges;
2. the industrial involvement in the conceptual design phase and more generally in the construction of RIs: need to develop the upstream business model (*industry as a supplier*);
3. what *Research* performed in the RIs – as distinct from *Development and Testing* – can bring to industrial R&D and innovation; that is a hybrid use of research could be promoted to develop downstream business models (*industry as a user*);
4. the interrelationship of Technology and Knowledge Transfer – and "co-creation" – in the two abovementioned models: need to understand correctly their respective roles;
5. the attractiveness of the RIs for industry: need to clarify various issues including the establishment of concerted and mutually beneficial Intellectual Property Rights (IPR) agreements; human resources; the crucial role of data policies, of intermediaries and cooperation schemes; and the access policies;
6. the broad range of socio-economic impacts of RIs: comprehensive identification of all their dimensions, need to evaluate and to integrate them in RI innovation policies.

1. The Research Infrastructures in the innovation chain

1.1. Diversity of forms of RI-Industry interactions

While there is a huge diversity of types of RIs, there is also a very broad range of interactions between individual RIs and their surrounding economic and industrial environment, representing to some extent potential opportunities for innovation. The concrete mix of such interactions, their absence or presence, as well as their intensity and relevance will vary substantially depending on the nature of a RI, the specific character of its wider innovation ecosystem, and the strategic objectives that the RI is pursuing. However, these interactions can and should be managed as a part of the overall mission and of a pro-innovation strategy of individual RIs. To realise this, they require dedicated mechanisms and, in some cases, dedicated staff able to interface with the whole range of potential stakeholders of the facility. Moreover, innovation and industrial cooperation are obviously important factors that strengthen the RI long-term sustainability and contribute to the broadening and diversification of international cooperation links.

The full breadth of such potential interactions may lead to additional socio-economic benefits, starting from those which are more commonly associated with research activity such as publications, to those that are more commonly linked with technology transfer, such as licensing and spin-off creation. Each RI requires a tailor-made approach to selecting and managing its interactions with its economic environment, whether acting as a platform to conduct collaborative research or as an enabler or service provider.

New knowledge production and dissemination

- *Publications*: the most common and traditional type of interaction for researchers; a carefully managed publication strategy may increase the impact of a RI on both the industry and user communities, while not compromising other strategic objectives pursued by the RIs related to commercialisation of their proprietary IP.
- *Access to data and ways of accessing them*: for many RIs data collection, storage and processing represent a key feature and sometimes even a raison d'être (e.g. specialist databases); considering the wealth of data, the opportunities for using them as a source of innovation – including social, societal, public sector innovation – and new applications are substantial, provided that adequate access support mechanisms and interfaces are in place.
- *Workshops, popularisation, communication*: this more conventional means of disseminating scientific knowledge should not be underestimated as a potential source of interacting with industry and of economic spill-overs; as in the case of a publication strategy, a carefully designed communication strategy of a RI and a well-targeted dissemination of its results may include also relevant fora and networking formats for meeting and networking with industrial partners.

Training and human capital development

- *Training*: while not a traditional mode of interacting with industry, the transfer of knowledge and know-how through training – on demand of industry, or targeting specific industrial user groups – may bring substantial benefits for the collaborating industrial partners while developing a community of users around RIs.
- *Staff mobility*: training of PhDs at RIs who subsequently find their way to employment in industry represent probably the most effective means of interacting with industry and of technology and knowledge transfer; similarly, dedicated schemes allowing industrial experts secondments at RIs represent a simple but effective way of extending the innovative ecosystem around the RIs as they often

form a basis for other types of longer term collaborations and interactions – provided that IP issues are properly addressed.

- *Access to infrastructures, including provision of specialist service and expertise*: this type of interaction, once appropriate access and charging mechanisms are in place, opens up new opportunities for industrial partners that would otherwise be inaccessible to them due to prohibitive cost of equipment and high cost of qualified personnel; often they may be combined with specialist training for users.

Contribution to new economic activities

- *Design and co-design of instrumentation and equipment, including innovative public procurement*: while relevant mainly in the construction and upgrade stages of RIs, this type of interaction carries a huge innovation and technology transfer potential. By formulating novel specifications that in some cases require radically new technological solutions this type of interaction may lead to the creation of new technological platforms – the RIs obtaining a new instrumentation subsequently used as a reference for a wider application field – and new markets – the company producing a new product or service with potential applications in other fields. Although it must be said that this type of interaction is likely to be limited to a relatively small group of high-tech, high value added companies, the benefits of such interaction are likely to translate into high value added and high growth for industrial partners.
- *Joint research projects with industry*: this type of interaction usually requires a dedicated funding mechanism as well as a dedicated interface, including a mechanism that identifies and selects the topics and partners for future research. While this type of interaction can form the bedrock of innovative science, the importance of balancing out the scientifically challenging research with industrial needs is key.
- *Contract research, including testing*: provision of specialist R&D services for a fee represents a common type of interaction between RIs and industry; yet often these interactions represent more than just a unidirectional transfer and may equally generate lasting partnerships as well as important scientific challenges and advances.
- *Licensing of IP*: this type of interaction represents a more conventional type of transfer of technology, usually carried out by a dedicated unit – tech transfer office – within the RI. However, the IP policies may vary substantially among RIs depending on their nature thus making this form of interaction much more relevant with some RIs than with others.
- *Spin off creation, business incubation and acceleration services*: similarly, this type of interaction may only be relevant for certain categories of RIs, the existence of a dedicated mechanism for identification of commercially viable ideas and their targeted support through incubation and acceleration services represents a powerful means of stimulating economic spill-overs of RIs.

1.2. The two main models of RI-Industry relationships

RIs operate in a very complex and outstandingly competitive context. Each RI is involved in an intellectual competition at national or international level – depending on its ambitions – in which excellence is the main driver. Competition to attract the best top-level users producing prestigious papers, to recruit the best operators, to get the best experimental components, etc. is the major objective of the RI managers aiming to valorise considerable investments made by the public sector.

Industry as a supplier: the upstream business model

The permanent race for the best valuable investment forces RI managers to seek industrial suppliers of unique components and services at the cutting-edge of the technological possibilities. In this particular context, failure is not acceptable and reducing the level of requirements quickly leads to a downgrade compared to competitors. It is also important to emphasize how the market for RI equipment becomes an "innovation leader" significantly ahead of the larger market for public and private laboratory equipment.

In the construction and major upgrade stages of RIs – design, engineering, commissioning – industry acts mainly as a provider of state of the art technologies, new designs, components, software, under standard procurement conditions or in closer collaborative conditions. RIs and industry are working – often in the same place – on shared problems leading to equally-driven objectives and maximizing the exchange of technology and competence. Technology Transfer (TT) happens more likely in the construction / upgrade stages: here TT runs in a "co-solution" mode, where scientific and industrial partners develop solutions on shared problems, often under the very pressing deadlines

of the construction schedule. This differs from more conventional approaches to TT between scientific institutions and companies, where companies have problems to solve and ask for solutions; or where patents made by scientists are brokered to industries. In this instance, a real co-operation is missing, i.e. sharing of objectives and solutions which are useful to both partners – e.g. the win-win condition for the RI to build an instrument and for the company to sell its new product.

Industry as a user: the downstream business model

Knowledge Transfer (KT) compared to TT is something acting in the medium-long term and aiming to create – more than transferring – new technology. This requires new research and happens more likely during the RI's operational phase. During this phase industry is a user of the experimental facilities – and of the data – for early stage basic research and more applied industrial research – often in cooperation with academic teams – and for testing innovative developments and products. Additionally, industry uses RIs for training and within the framework of exchange programmes. The use of the facilities is directly linked to various access regimes which were defined in the European Charter for Access to RIs[1].

- *Excellence-driven access* is exclusively dependent on the scientific excellence, originality, quality and technical and ethical feasibility of an application evaluated through peer review. It enables collaborative research and technological development efforts – with the RI and academic teams – across geographical and disciplinary boundaries, with "innovation" as an outcome; the results are published.

1. The Charter of Access to RIs has been developed by the Commission in close cooperation with the ESFRI, the e-IRG and the ERA Stakeholder Organisations. This charter sets out non-regulatory principles and guidelines as a reference when defining access policies for RIs. The charter also promotes interaction with a wide range of social and economic sectors, including business, industry and public services
https://ec.europa.eu/research/infrastructures/pdf/2016_charterforaccessto-ris.pdf

- *Market-driven access* is defined through a negotiation between the user and the RI that will lead to an agreed fee for the access. Examples are: proprietary research at full cost or other specific contractual conditions – e.g. for the development of highly advanced technologies. The results are – partially – not published.
- *Wide digital access* guarantees the broadest possible access to scientific data and / or digital services provided – e.g. by e-Research Infrastructures – to users wherever they are based.

1.3. RIs within ecosystems of innovation

Research Infrastructures are privileged places where research meets innovation and industry – in the form of industrial applications, technologies and business. They bring together highly skilled scientists, engineers, technicians and managers, funding agencies, public authorities, policy decision-makers and industry, including SMEs. RIs are characterised by their scientific and technical multi- and cross-disciplinarity and a mix of a very broad range of interactions with their economic and societal surrounding environments.

RIs are major drivers of – industrial – innovation: in their construction and major upgrade phases – design, engineering, commissioning – as sources of (pre-)commercial procurements and purchasers of new high-tech components, instruments and related services; in their operation phases, as facilities serving industrial research and innovation, offering opportunities to remove technological barriers leading to further innovation and to generate knowledge transfer. This framework is illustrated through **Figure 1**.

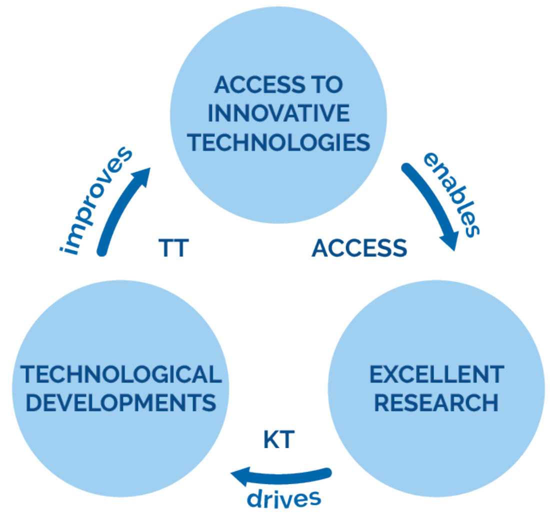


Figure 1. The virtuous circle of innovation

RIs offer an environment that generates a high flux of peer reviewed proposals and experiments stimulating international collaborations and where several scientific disciplines and economic sectors cross together – physics, chemistry, biology, Earth sciences, energy, cultural heritage, food, etc. They provide a critical mass of instrumentation available or the capability to develop new one and are able to mobilize rapidly – with very short delays – their capacities in order to find solutions to the industrial demand.

RIs can offer industrial companies to be immersed in active ecosystems of innovation based on their complementary broad range of competences and skills. They are indeed most often located in S&T areas that include state of the art enabling technologies and support services – nanotech cleanrooms with chemical hoods and glove-boxes, fine analysis and characterization labs with electronic and scanning probe microscopes, bio-labs, optical labs, mechanical and electronic workshops, ICT support for data storage and analysis, etc. Such an environment enables the creation of a unique ecosystem around RIs well suited for innovation where research teams, standards and metrology services, small high-tech enterprises, spin-off and start-up companies, detached labs of big companies, Technology Transfer and Industrial Liaison Offices staffs all together exploit the "business at walking distance" advantage in working together on common issues in the same place.

The development of local or regional ecosystems integrating RIs, Technology and Service Providers, Incubation Facilities and Industrial Users should be promoted, namely an environment opening new room and opportunities around RIs for hosting projects with industry and where the added value offered by RIs and their complementarity with industry can be optimized – in scientific campuses, technology parks, etc.

However, it should be noted that a tension may exist between: (i) on the one side the development of the innovation ecosystems around RIs which is happening in privileged "isolated" hubs and (ii) on the other side the need to strengthen proximity relationships with the whole industrial fabric – this implies to develop a set of RIs well distributed in all parts / regions of the EU. The specificities of the distributed RIs should also be further analysed and used in this regard.

1.4. RIs and Technology Infrastructures

The new concept of Technology Infrastructures (T-Infrastructures) was proposed in 2015 starting from the recognition that one should move from a science-driven model for the building of independent RIs to a new science and technology-driven collaborative model. Size and time-scales of pan-European and global RI projects make the current independent RIs model not sustainable for industry. In particular, the risk of duplication of R&D efforts is high within a context where resources to invest in highly innovative technologies are limited. Examples were given for the accelerator and accelerator-based technologies, cryomagnetism, etc. The new collaborative model favours the development of common R&D and construction capabilities, of large-scale platforms gathering highly innovative R&D and large-scale assembly, integration and verification facilities. Grouping technological needs will help to create a viable – global – market, building on a – long-term – shared technological vision and fostering sustainable connections with industry, including possible joint operation of the facilities.

T-Infrastructures are a key route to societal and economic impact and could stimulate science and innovation clusters and increased and improved cooperation with industry. They should be fully integrated in the landscape of the innovation ecosystems. Roadmaps and strategic agendas for key technologies for the R&D and construction of RIs based on platforms of significant size should be jointly defined. In particular, a supporting infrastructure for generic assembly, integration and test facilities should be developed at European level in association with industry – public-private partnership. It is notable that the Horizon 2020 Call on "Fostering the innovation potential of RIs" – H2020-INFRAINNOV-2016 / 2017 – provided funding for the coordination and networking of T-Infrastructures involving RIs, industry and SMEs.

1.5. RIs and Grand Societal Challenges

Innovation should be considered in all its aspects. Indeed, RIs serve science and technology but also policy-making and society. The social, societal, ecological and public sector dimensions of innovation are particularly important for RIs in the Environmental, Health and Food and Social Sciences and Humanities sectors (and also for Analytical Facilities). Most of them were built for their mixed scientific and societal impact, providing new knowledge, data and services to increase the security, well-being and prosperity of a society faced with a series of Grand Societal Challenges (see the **BOX 1**, **2**, **3** with examples of **ESFRI Landmarks facing with Grand Societal Challenges**).

ESFRI LANDMARKS FACING WITH GRAND SOCIETAL CHALLENGES, HEALTH & FOOD DOMAIN

Biobanks and biomolecular resources (e.g. BBMRI) shall develop into one of the most important tools in biomedical and clinical discovery. New medical applications, new therapies, new preventives, new diagnostics, drug development, personalised or stratified medicine and new biomedical industries shall evolve to improve socio-economic competitiveness and increasing possibilities for equitable healthcare in Europe. The close collaboration between researchers, biobankers, patient advocacy groups, and the biotech and pharmaceutical industry is essential in addressing both common and rare diseases as well as Grand Societal Challenges regarding the health of the ageing population.

The **European Infrastructure for Translational Medicine** (EATRIS) will improve the output of novel medicines and diagnostics and have a considerable socio-economic impact in Europe and globally. It is focused on supporting in bridging the gap to industry in medicine development where a great deal of capital-intensive applied research is necessary to bring a new drug to a point in which industry becomes interested (the so-called "Valley of Death").

The **European Clinical Research Infrastructure Network** (ECRIN) supports multinational clinical trials in Europe. Clinical trials are essential tools for the development of health innovation and treatment repurposing. They have a strong positive impact on the health industry (medicines, vaccines, medical devices, diagnostics) and nutrition industry sectors, and on citizens' health. They improve healthcare strategies (with a measurable economic impact on wellbeing and productivity) and healthcare cost containment.

The **European Research Infrastructure for the generation, phenotyping, archiving and distribution of mouse disease models** (INFRAFRONTIER) offers open access to highly standardized and strictly quality controlled resources and services. The disease models available can be used to address basic and fundamental scientific questions about in vivo gene function and may further our understanding of disease genetics. Mouse models are used by biopharmaceutical companies for addressing more applied questions ranging from the identification and validation of novel drug targets to the analysis of drug action and side effects and safety and efficacy testing of potential drugs.

The **Integrated Structural Biology Infrastructure** (INSTRUCT) provides access to a broad integrated palette of state-of-the-art technology and expertise as well as training and technique development in the area of integrated structural and cell biology, with the goal of promoting innovation in biomedical sciences. Industry (pharmaceutical and many biotechnology companies) is a major user of structural biology infrastructure as key tools embedded in their drug discovery pipeline (e.g. against infectious diseases). Integrative structural biology will also allow a faster, more coordinated response to new threats such as pandemics or bioterrorism. In addition, there is considerable not yet realised potential to contribute to the design of innovative, effective and safe vaccines.

BOX 1. ESFRI Landmarks facing with Grand Societal Challenges, Health & Food domain

ESFRI LANDMARKS FACING WITH GRAND SOCIETAL CHALLENGES, ENVIRONMENT DOMAIN

The **European Multidisciplinary Seafloor and water-column Observatory** (EMSO) connects fixed point open ocean nodes, aimed to study and monitor European seas, and to support the sustainable use of the marine environment and a consequent growth of markets directly related to it. Investment in ocean observatories is critical to assess and monitor environmental conditions, track climate change, expand seasonal forecasting, address safety at sea, develop applications for the offshore industry and fisheries, respond to accidents and pollution, and aid defence requirements. The RI will provide data essential to addressing a wide range of important challenges and threats like: natural disasters (e.g. earthquakes, tsunamis); overfishing; pollution (including noise); habitat destruction; invasive species; and climate change.

The floats of the **European ARGO system** (EURO-ARGO) will contribute to long-term global ocean observations (ARGO). Given the prominent role of ARGO for climate change research, its contribution to and impact for seasonal and decadal climate forecasting, socio-economic impacts are expected to be large on the longer run. Long-term global ocean observations will lead to a better understanding and prediction of climate change (e.g. sea level change) and improved mitigation strategies. The *Copernicus Marine Environment Monitoring Service* deeply relies on ARGO *in situ* data. Investing in such global ocean observations has a high benefits/costs ratio. The other major non-academic users are ocean services and the *Copernicus Marine Service* (e.g. maritime transport, marine safety, fishery management, oil pollution monitoring and forecasting, offshore industry).

The **In-service Aircraft for a Global Observing System** (IAGOS) operates a global-scale monitoring system for atmospheric composition by using the existing provisions of the global air transport system. It collects crucial data for users in science and policy, achieving a level of data quality that other measurement methods would not be able to attain. Regular in-situ data from airborne platforms is essential for evaluating and improving the quality and accuracy of numerical model predictions for air quality, weather and climate change on the global and regional scale, as well as for validating and calibrating data from space-borne remote sensing. The RI provides also observational data directly to aviation industry and airlines for improving operation procedures and thus reducing costs and enhancing aviation safety. More specifically, it is provided for climate models, including those used by the *Copernicus Atmosphere Monitoring Service*, and for the carbon cycle models employed for the verification of CO_2 emissions and Kyoto monitoring.

The **Integrated Carbon Observation System** (ICOS) provides data and knowledge on greenhouse gas (GHG) budgets and their perturbations. The RI is involved in the IPCC, the Group on Earth Observation and other global initiatives. Deeper understanding of the driving forces of climate change requires full quantification of the GHG cycles. Regional GHG flux patterns, tipping-points and vulnerabilities can be assessed by long-term, high precision observations in the atmosphere and at the ocean and land surface. The United Nations Framework Convention on Climate Change (UNFCCC) requires from Parties to monitor essential climate variables and the reporting under the Convention and Kyoto Protocol requires emission inventories. ICOS data can be used to increase the quality and to verify those inventories. Ecosystem observations conducted within ICOS may also provide important knowledge on ecosystem responses to climate change and climate extremes that can be used for food security estimates.

BOX 2. ESFRI Landmarks facing with Grand Societal Challenges, Environment domain

ESFRI LANDMARKS FACING WITH GRAND SOCIETAL CHALLENGES, STRONG E-INFRASTRUCTURE COMPONENT

SOCIAL SCIENCES AND HUMANITIES (SSH)

Providing pan-European cross-border access to important (sometimes unique) **social science data collections** (e.g. CESSDA) will enable use and re-use of high-quality data sets (produced within publicly funded projects). These data are a form of capital investment without which it would be impossible to measure and understand ongoing economic and societal dynamics, the problems involved and the solutions available. European and national economic and social benefits achieved through membership of CESSDA should be clearly visible to policymakers and thereby impact directly on decision making, including in the private sector.

The **Common Language Resources and Technology Infrastructure** (CLARIN) aims to facilitate SSH research by offering a single entry point to find and use vast amounts of collections of digital language data (in all forms: text, audio, video and other modalities) as well as advanced tools to explore, exploit, analyse, enrich or combine them.

The **Digital Research Infrastructure for the Arts and Humanities** (DARIAH) aims to play a pioneering role in the use of big data technologies for research, in trusted digital repositories, in virtual research environments, etc. It will contribute to the development of the European knowledge economy and of the creative and cultural industries.

The **European Social Survey** (ESS) responds to the academic, public policy and the societal need for rigorous cross national data on social attitudes and behaviour in order to understand social stability and change within a European context. It provides comparative data which can inform public policy development and assessment, and support evidence based policies.

The **Survey of Health, Ageing and Retirement in Europe** (SHARE) is a multidisciplinary and pan-European panel database of micro data on health, socio-economic status and social and family networks (collected in interviews).

It aims at documenting and better understanding the repercussions of demographic ageing for individuals and society as a whole, and forming a sound scientific basis for countermeasures adopted by health, social and economic policy. For example, it has helped to support increases in the labour force participation of older citizens and shown that early retirement has positive as well as negative effects on health and cognition (and has shed light on who enjoys the positive and who suffers from the negative effects).

HEALTH

Investment in a sound **infrastructure for biological data** (e.g. ELIXIR) creates a foundation for all aspects of life science research from biodiversity, agriculture to human health. Many companies – ranging from small biotech companies through to large publishers – build commercial services directly on top of public data resources or integrate these public data into their services. These knowledge-based companies depend on the sustainable, interoperable resources provided by ELIXIR partners. This public data infrastructure underpins commercial discoveries and translations across Europe's life science industries and leads to new drugs and effective treatments, more environmentally-friendly products and higher-yielding crops. All these developments are crucial for society.

ENVIRONMENT

The LIFEWATCH **infrastructure for biodiversity and ecosystem research** is operating an e-Infrastructure for basic research on biodiversity and ecosystems, and supports research for the protection, management and sustainable use of biodiversity. Biodiversity loss is one of the top societal challenges today, and a matter of concern at global, regional and local levels. Biodiversity loss is increasingly influenced by anthropogenic induced impacts which can be summarized in population pressure and climate change, resulting also in environmental constraints such as desertification, reduced water availability, and land-use change, among others. The increased knowledge of the impact of biodiversity on the functioning of ecosystems helps to make sound decisions for avoiding anthropogenic impacts on ecosystems and biodiversity and to devise cost-effective management plans.

BOX 3. ESFRI Landmarks facing with Grand Societal Challenges, strong e-Infrastructure component

The ESFRI RIs developed creative approaches to enhance their industrial cooperation in this perspective too. The objective is to enable the public sector to improve and modernise public services faster while creating opportunities for companies in Europe to gain leadership in new markets. Numerous examples of good practices can be given regarding the provision by ESFRI RIs of data and scientific public services, their contribution to the monitoring, follow-on and preparation of public policies, etc. Several of them are described or mentioned in different parts of the report.

Figure 2 – freely inspired from the Association of European-Level Research Infrastructure Facilities (ERF) discussions – provides an interesting general picture of the very broad range and sometimes complex interactions between RIs and their surrounding techno-scientific, socio-economic and societal environment.

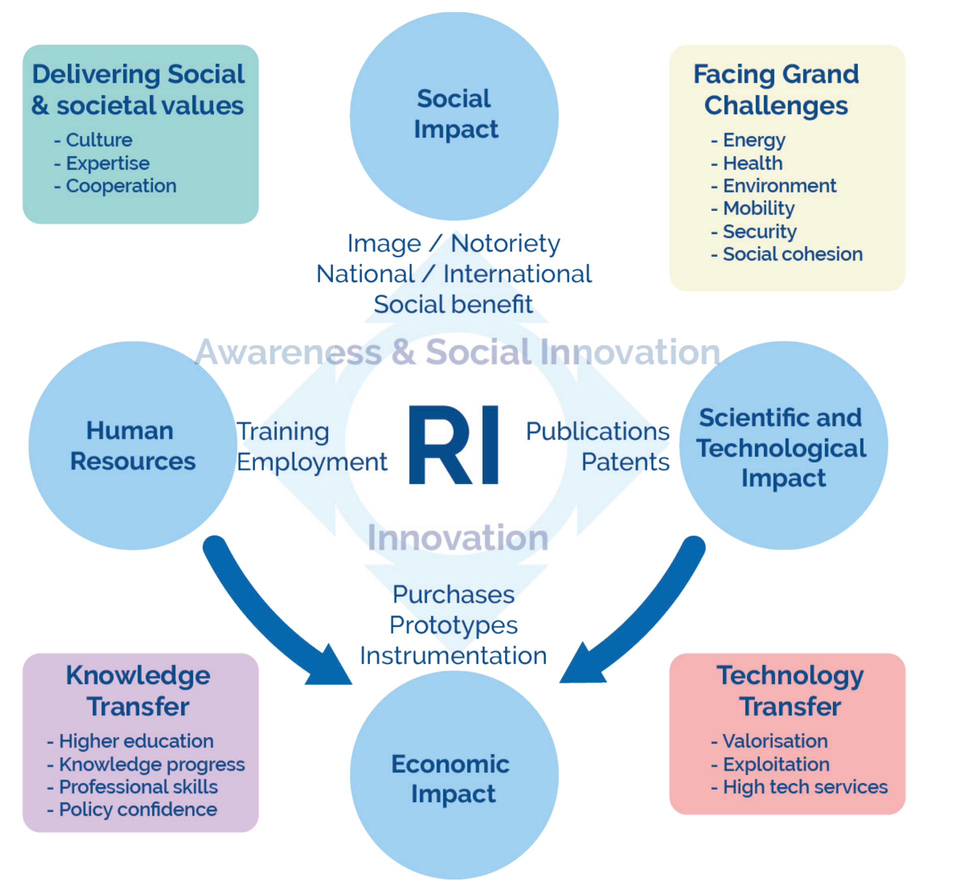


Figure 2. Interactions between RIs and their surrounding techno-scientific, socio-economic and societal environment

2. Industry as a supplier - the upstream business model

Most of the RI experimental installations are custom-built as a result of a tight collaboration between research teams and private companies, including high-tech SMEs. Particle beam accelerators, optical components for X-rays, detectors and GRID systems are a few examples where vacuum technology, new materials for sensors, power supply, data storage / handling capabilities and safety issues are brought to the limit. On one side the RI wants to achieve a top score of the experimental parameters, on the other side the supplying company is willing to enhance its product or its process and to improve its brand or its reputation in a very short time. The RI's technological units are in charge of the integration of the new instruments in the facility in order to open them quickly to the academic and industrial users. One can recognize that the competition between academic users often leads them to urge the RI for commissioning as soon as possible the new experimental device they require. In that way a RI becomes a unique place for reducing the "time to market" of the revolutionary device to be installed, which is intended to bear the outmost innovation.

RIs are playing a dual role: as innovation providers on the one hand and technology purchasers on the other hand. The innovation process is strongly pushed by the leverage effect of public procurement. Such a context creates a shared driving force which stimulates the exchange of technologies and competences and boosts common motivation and efforts. Once tested and used for the project, these newly produced devices will be subsequently integrated into products or processes to be sold to academic and private laboratories. In the same time the results published in highly ranked scientific journals will increase the scientific outreach of the facility and potentially allow getting more resources for ensuring the development of new outstanding instruments. Similar conditions exist in the upgrade stages and in general when new instrumentation has to be developed; in some cases, also in the decommissioning phase.

2.1. Technology Transfer

In these conditions, Technology Transfer (TT) is effectively realized whenever an existing technology is transferred from a field of application to another one, or by one entity to another one – the industrial supplier, the RI staff, the final user. Each transfer step typically gives rise to an incremental innovation related to the specific technology embedded in the specific field of application.

During the construction of new RIs, the upgrade of existing ones and in general the procurement of large instruments, including the maintenance of complex plants – cryogenics, superconducting, ICT, energy supply – a concrete and very effective TT takes place, in both directions, from RIs to industry and *vice versa*. Home-made native technologies developed as proof of concept at the RIs laboratories and workshops are, at a certain moment, given to specialized industries – often local SMEs – for the complete engineering fulfilling the final request. On the other hand, technologies which are available on the industry side are requested by the RIs and asked to be pushed at the limit, or improved for over-state-of-the art applications. In such a context TT is very effective because both partners – scientists and industrials – are strongly motivated: the scientist to get the best solution for the attractiveness of the facility and the industrial company to sell its product. They work usually together in the same place on the same problem. It is easy to understand that such a TT which is well established in the context of RIs is one of the most effective methods of implementation of TT between academia and industry, when compared with more common approaches to TT, like brokering of technologies, promotion of patents, problem solving services, B2B events where the motivation is polarized mainly on one of the two parties – three, when including the broker which is more likely at the very end the most motivated one. There are many other contexts where TT is effective, from industry to industry or from technological infrastructures / platforms to industry but most frequently where an established technology already exists.

Therefore, in the upstream model where industry is a provider and TT appears to be in the best conditions, we don't need to look for new business or relationship models but we just have to focus on the weaknesses affecting such a model in order to improve it and to improve the opportunities for the industrial partners. In particular, something can be still done to increase the industrial return and the societal impact of RIs. Indeed, the procedures of procurements and calls for tender are the formal interface between RIs and industry in such a context. On one side, one could try to open up the possibility to participate to the RI development to a wider industrial community, seeking new partners and maybe involving more member states; while on the other side trying to improve the current bureaucratic procedures. On the industrial side, internationalization and manufacturing according to the highest international standards are mandatory keywords to be competitive at European level.

2.2. Needs expressed by industry

The main difficulties experienced by commercial companies as suppliers of RIs can be briefly described as follows, on the basis of the needs expressed by various industry representatives.

Industry wishes to be involved at an early stage of large projects with RIs although stresses that it is currently very difficult. The demand from industry is often at the limit or even above the state of the art. Nevertheless, engineering should preferably be done in collaboration with industrial partners rather than by laboratories alone. But it is indeed extremely difficult to industrialize internal designs coming from labs when industry has not been involved in design at an early stage. Moreover, SMEs are sometimes disadvantaged by competition from government labs. It is also pointed out that RIs should present their specifications in a more flexible way, being more general and functional and thus leaving more room to initiatives from and with industry.

Awareness – as early as possible – on RI opportunities and offerings for industry should be raised.

First, the need for a central portal – which has already been expressed in many previous studies and stakeholders' meetings – is recalled. There is indeed an obvious lack of advanced and harmonized information especially on RI services, (future) Calls for Tenders – with information on available budgets, not compromising competition and negotiation capacity –, future RI needs and TT opportunities, and upcoming procurements.

More generally, the role of Industrial Liaison Officers (ILOs) is crucial and should be well coordinated by the different RIs in order to help industry to plan its internal activities and investment strategy – expertise, human resources, and industrial means. Good practices are mentioned: information days, webpages and databases;

market surveys; phasing of new developments; coordinated public support given at national level in some countries. Obviously the more the ILO is acting as a professional entirely devoted to his / her task, the more successful is the collaboration.

Harmonisation of the structure and information content of tender requirements – including a maximum requirement – would be very welcomed by industry because usually each call has different standards and requirements which costs a lot of additional efforts overall. Legal clauses can be extremely demanding for suppliers and IPR requests from some organizations can limit the possibilities to capitalize on the development. It has been suggested to keep a part of tenders for SMEs. The procurement procedures and rules are also not harmonized in the different countries because the relevant European directive is not transposed in the same way in all countries. Moreover, industry considers that open competition does not protect the interests of EU companies whereas USA and Japan have a far more supportive approach to their industry. The new EU regulation on innovative partnerships (2013) could play a stimulating role in this regard.

For industry, there is lot of space for improvement with in-kind contributions which currently give advantage to large companies. In-kind supplies are often based on (academic) laboratories choices rather than on shared laboratories-industry strategy. A joint approach taking into account the labs' domains of excellence or interest and the domestic industry capacities and strategy should be promoted.

Summarizing, on the base of these views expressed by industrial representatives, the concept of "industry as a full partner" should be put in practice more proactively; this implies to promote more extensive partnerships on joint R&D projects and cooperative programmes, including the development of advanced technologies and innovation, training and exchange programmes, etc.

2.3. Regulatory and financial issues

Public procurement policies

Each new technological device is a challenge that requires to be designed in close conjunction with a manufacturer who implements it under contracts guarantying a reasonable Return On Investment (ROI) for the company. Furthermore, the joint management of the technological risks is able to guarantee that the development of the components will be appropriate to the RI's market. Background technological developments are sometimes jeopardized by the obligations that are imposed by the public procurement policies to the research facilities to set-up open calls for proposals once it has been decided to procure the ad hoc components. This leads industrial companies to perceive some calls – that are fully compliant with the regulations in force – as a "mascarade of call" where all tenders would know in advance which company will be chosen – sometimes the call is declared as "unproductive" and cancelled, inducing delays of delivery. Situations where the developer is at risk in being forced to share its advance with other competitors – competitive dialogue in unfair conditions – have also been reported. All these situations are denounced by the industrial companies usually supplying advanced components to the European facilities. They suggest in particular a special clause guarantying the initial developer to be granted for its investments – whatever the final result of the call(s) for tender related to the component(s) in which he has been involved in the development. The INNO WG does not necessarily share all these views but they reflect real difficulties. It is the reason why it should be wise to try to consider possible improvements to the processes of public procurement aimed to better involve industry in pre-commercial research and prototype development, taking into account the difficulties expressed by all stakeholders.

The important issues of Pre-Commercial Procurement (PCP) and Public Procurement of Innovation (PPI) were addressed by the Work Programme 2014-2015 of the Horizon 2020 / RI Programme, under the Call for proposals INFRASUPP-2-2015 on Innovative procurement pilot action in the field of scientific instrumentation. Also, basic mid-term data from FP7 funded PCP projects shows – as pointed out by the European Commission (EC)[2] – that PCP are opening route-to-market for new players and SMEs and are stimulating cross-border company growth. It should be further investigated how RIs could make use of this scheme.

Public procurement leverage effects – long-term markets – of the schemes – PCP and PPI – aimed to better involve industry in pre-commercial research and prototype development can be expected. The procurement procedures and rules need to be simplified and their transposition should be better harmonized in all EU Members States.

A "Guidance for public authorities on PPI" intended for purchasers as well as for industrial suppliers has been published in 2014 by the European Commission[3]. It is in particular based on a European directive which has been transposed in all Member States at very different levels of detail. It should be noted, however, that a PPI for RIs is always coping with international transactions and a variety of possible declensions. This guide should thus be complemented by a practical manual of application in each Member State so that the provisions of the EU directive can be really helpful for all RI stakeholders. Indeed, the procurement procedure must be conducted jointly by the prescriber – the "techno-scientist" managing the RI – and the procurement officer.

2. Results from EU funded Pre-Commercial Procurements https://ec.europa.eu/digital-agenda/en/news/mid-term-data-fp7-funded-pre-commercial-procurement-pcp-projects

3. Guidance for public authorities on Public Procurement of Innovation https://www.innovation-procurement.org/fileadmin/editor-content/Guides/PPI-Platform_Guide_new-final_download.pdf

It is important that they share the same information regarding the large variety of procurement actions which can be implemented by the facility: by mutual agreement, innovative procurement, conditional steps, etc. This guide would also be a good way: (i) to stimulate an internal dialogue with all interested parties (procurement officers, engineers and researchers) in order to raise awareness in RIs and industry; (ii) to train young scientists in RIs to better cope with the industrial research requirements and TT and (iii) for industrial staff to become better acquainted with the innovation potential of RIs.

RI markets

The realization and use of specialised studies devoted to RI markets should be generalized. European RIs are obviously suffering from a dramatic lack of competencies and consultants specialized in market studies devoted to cutting-edge innovative components and RI calls for tenders. Europe is supporting world-class RIs, these must also consider the worldwide markets for the selection of their suppliers. In this context, the European RIs should overcome their internal rivalries and not fear potential competition if they maintain a reasonable effort of technological R&D in partnership with industrial companies and ensure the global dissemination of their joint innovations. Each funding request for supporting the development of an innovative component or service to be implemented in a RI should include a market study demonstrating the potential extension of the commercial opportunities to other RIs. This implies that the emergence of independent specialized services in market studies applied to RIs – such as Knowledge Transfer Network (KTN) in UK or the Bureau d'Études Marketing du CEA (BEM-CEA) in France – should be facilitated. Moreover, at regional level, socio-economic impact could be addressed in the context of Smart Specialisation Strategies.

Support to technical developments in European companies

European SMEs are regularly solicited by RIs but they have to be able to quickly develop new components or develop and adapt existing ones to meet the requirements of RI equipment projects. The access of such companies to EU rapid funding mechanisms such as the SME instrument or the "Fast Track to Innovation" might be explored as it is done in the USA. In agreement with the Horizon 2020 regulation, these instruments can support innovation actions under the specific objective "Leadership in enabling and industrial technologies" and under the priority "Societal challenges", with a bottom-up-driven logic. Under the current regulation, it cannot be supported by the "Excellent Science" priority and therefore not targeting the needs of RIs only.

The Commission, with a bottom-up driven logic, wants to ensure that the most innovative actions will be selected. SMEs serving RIs needs are fully eligible and therefore encouraged to apply to these instruments, as long as they have the potential to grow, in particular beyond the RIs market.

Rules regulating State Aids

Another possible step forward which might be appropriate for enhancing innovation in RIs was raised, namely to revisit the regulatory requirements related to the granting of State Aid with regard to RIs in increasing the so-called "economic activities" limits which allow them to benefit from tax exemption. The Commission provided information on the rules which are in force since July 2014. These rules should facilitate the granting of aid measures by Member States in support of Research, Development and Innovation (RDI) activities.

The new RDI State Aid Framework sets out the conditions under which Member States can grant State Aid to companies to carry out

RDI activities. Member States can now grant higher aid intensities which should provide enough margins to cover the "financing gap" of R&D-investments – i.e. the part of the project that cannot get private funding. Moreover, the scope of measures that no longer need to be notified to the Commission for prior approval has been widened under the new General Block Exemption Regulation (GBER). The aid for the construction or upgrade of RIs is a new exemption category. The threshold up to which aid can be granted under this category without prior Commission scrutiny is 20 million €. Furthermore, the new GBER also extends to pilot projects and prototypes, innovation clusters and aid for process and organisational innovation.

See also the **BOX 4** with complementary information on **Loans and guarantees from the InnovFIN Large Projects.**

LOANS AND GUARANTEES FROM THE INNOVFIN LARGE PROJECTS

RIs can benefit from loans and guarantees from the InnovFin "EU Finance for Innovators" instrument, a joint initiative of the EIB Group and the European Commission under Horizon 2020. It builds on the Risk-Sharing Finance Facility developed under FP7, which for the period 2007-2013 financed 114 projects of 11.3 billion € and provided loan guarantees for another 1.4 billion €. *"InnovFin Large Projects aims to improve access to risk finance for R&I projects emanating from larger firms; universities and public research organisations; R&I infrastructures (including innovation-enabling infrastructures); public-private partnerships; and special-purpose vehicles or projects (including those promoting first-of-a-kind, commercial-scale industrial demonstration projects). Loans and guarantees from 25 to 300 million € will be delivered directly by the EIB".*

BOX 4. Loans and guarantees from the InnovFIN Large Projects

2.4. The need for pre-integration platforms open to industry

As it was pointed out in **Chapter 1**, the design of large-scale facilities or complex equipment for specific environments require the use of large technological platforms – test-beds, mega-vacuum chambers, testing pools – where the scientific communities, helped by high-level engineers, bring their specific competences and develop innovative techniques to reach the scientific goals; some industrial partners are associated with the construction phase. This is the case for physics, energy, engineering, marine or space sciences where large-scale and complex and cutting-edge components are needed: unique mega-detectors, superconductivity chain, vessels for hostile environments, etc. This model suffers from several drawbacks. The workload of such platforms is erratic; there are necessarily gaps between the successive construction projects which hamper the sustainability of acquired skills, especially very specific competences such as those in engineering integration – at different levels of complexity – which are very scattered in various labs and industrial companies. Bringing them together is time consuming and doesn't guarantee a reasonable ROI to the stakeholders. Usually the period of reduced activity between construction and test phases are used to carry on technological R&D which is a good way to maintain capabilities as much as possible but this is not enough to limit the operating deficit of these platforms.

The EU could stimulate the setting-up of a public-private partnership – as a test – which would be devoted to the operation of a pre-integration platform, including the co-development of technological R&D between the RI construction projects - see H2020 RI Work Programme 2016-2017. The R&D programmes would be focused on key-components and elaborated in line with a strategic research agenda: accelerating devices, ultra-cryogenic systems, future lasers' chains, top level optical devices, sensors and actuators, undersea remote vehicles, electronics and RF systems, big data acquisition. These quasi-industrial "genuine high-tech products" shall facilitate the penetration of European companies within the RI market which is thriving at a worldwide level and in Southeast Asia in particular. This is also a unique opportunity for setting-up public-private partnerships stimulated by pre-commercial objectives. As a result, European "techno-scientists" working in these facilities are particularly solicited thanks to the "integration know-how" they are used to sharing with solid networks of high-tech SMEs able to respond to calls for proposals of non-conventional facilities. On a longer term and thanks to this experience the European industrial suppliers will be better positioned to bid for the construction of new global research facilities.

The **BOX 5** provides a miscellanea of **ESFRI Landmarks' current practices in industrial cooperation and innovation during the construction phase** (information extracted from a survey made by the EC in 2015).

ESFRI LANDMARKS' CURRENT PRACTICES IN INDUSTRIAL COOPERATION AND INNOVATION DURING THE CONSTRUCTION PHASE

E-ELT: INVOLVEMENT OF INDUSTRY IN THE CONSTRUCTION PHASE

Ca. 70 % of the construction cost returns to industry in the form of contracts, many for R&D and advanced technologies. Increased government investments in IT and high-speed, high capacity data networks are planned in anticipation of the E-ELT. Industry is a supplier for: feasibility studies, initial R&D contracts, construction of prototypes for the riskiest items. ESO works closely together with Europe's high-tech industry, e.g. regarding detector development. The results of this cooperation, in terms of improved instrumentation performance, are fed back to industry.

The impact on innovation activities will be significant. There will be several components, such as actuators, sensors, etc., that will be pushed in their actual state of the art performances to fulfil the requirements imposed by the project. Industry will explore and most probably find applications that will open new markets for business. The know-how will be made available for further exploitation according to the terms and conditions defined by the ESO Member States. The E-ELT will use advanced technologies and engineering solutions in a number of areas, from gigantic, lightweight high-precision structures, opto-mechanical systems, optical design, control systems etc. Many of these technologies will be applicable to other areas of technology development.

The E-ELT is considered a highly prestigious project and therefore industrial interest and preparedness to deliver extraordinary performance is manifest, as ESO has seen it in past projects (notably the VLT). ESO has since many years devolved its instrumentation programme so that science instruments are (largely) designed and built by national institutes, often in collaboration with industry. In this model, national facilities cover the human resources cost against compensation in guaranteed observing time.

ELI: CONSTRUCTION IMPACTS ON INNOVATION

During the construction phase, ELI has a considerable impact on innovations in laser technology and laser-based secondary sources through procurement of world-leading, mostly unique equipment. Suppliers include industry from many European and non-European countries, as well as world-leading RIs. Many of these custom designed lasers are expected to turn into commercial products, creating substantial future economic impact.

The medium- and long-term socio-economic benefits of the three nodes of the distributed RI will be: job creation (during/after construction, elsewhere); new well skilled professionals in the labour market; new partnership and networks (domestic or international); improved ability to collaborate and network; increase of the performance and yield of existing companies; new businesses entering the market; improved overall business environment and public services; attraction of global R&D investments; regional infrastructure development; education (actual or potential impacts); increased societal prosperity, satisfaction, equality.

FAIR: CONSTRUCTION AND TECHNOLOGICAL DEVELOPMENTS

The main purpose of building FAIR is basic research and cooperation with industry is occurring mainly during the construction phase. Some part of the expenditures for civil construction will be spent in the region of Darmstadt in Hessen, Germany. After start of operation, when significantly more scientists from all over the world will work for longer periods of time at FAIR, there will be also an impact to the region hosting the facility. Moreover FAIR will be beneficial for the scientific landscape in the host region and country.

Technical developments for the FAIR facility are/will be protected by patents and will be subject of TT. The international FAIR experiment collaborations with more than 2500 scientists are developing and building the FAIR experiments since about ten years. FAIR will provide services to these scientists as Host Lab in a way similar to CERN.

ESS NEUTRONS: THE “IN-KIND CONTRIBUTION” APPROACH

ESS is being built on a green-field site, a challenge which brings with it great potential, for society, as well as for science. Further scientific and technological advancements are required to build this unique facility, which is the best of its kind. Within the construction of ESS, a significant amount will be R&D related, which has a high potential for innovation. The construction will generate growth and jobs, advance development and fuel innovation potential in the region and across the EU. With ESS being built as a collaborative project, the growth effect will be shared between the region (Öresund), the host countries (Sweden and Denmark) as well all as the ESS Partner Countries. Most of the necessary skills for its development need to be imported through In-Kind Contributions (IKC) from participating institutes and companies in the Member States. The IKC approach is intended to foster collaborations between national academia and industry, representing the entire supply chain.

While the management and integration of IKC is challenging for a project organisation, it also provides significant and highly desirable advantages for the ESS itself as well as the member countries. Access to frontier technology that enables the realisation of ESS would otherwise be unattainable, as well experienced technical and scientific personnel and access to unique production facilities and technologies. This is a very important socio-economic driver in that the construction of ESS fuels national innovation potential, competitiveness, and the national GDP of all of the Member States for the long term. This will increase each country's national and cross-national capacity and help create jobs and growth.

EUROPEAN XFEL: INDUSTRY AS A SUPPLIER FOR THE CONSTRUCTION

The development of one of the technologies that are at the heart of the European XFEL, i.e. the superconducting RF (radiofrequency) accelerator technology, was conducted in close collaboration with industry. The need to couple state of the art materials and processes, developed in a publicly-funded research environment, with mass production of components, only possible in an industrial environment, made TT a *sine qua non* condition for the implementation of large accelerator facilities. Over more than 20 years, the TESLA world-wide collaboration, with a very strong European component (led by DESY), in collaboration with industry, developed and refined the technologies allowing the production of 2 km of superconducting RF cavities of extremely demanding specifications. As a result of the DESY leadership in the development of superconducting RF, European industry is today a market leader and a likely supplier of projects using this technology in Europe and in other continents.

Further examples are in the electronics domain: (i) with the extension of the Micro-TCA.4 standard of telecommunications to electronics hardware for the control of complex equipment (such as the European XFEL accelerator), by the DESY controls division in collaboration with industrial partners (to be adopted by the European Spallation Source in Lund (SE) as well); and (ii) with consortia of academic and industrial laboratories in Germany, Switzerland and Italy developing sensors and data handling electronics for innovative MHz frame acquisition rate detectors, under the impulse from the European XFEL.

SKA: GLOBAL COOPERATION

There are several ways in promotion of TT and KT along with the Square Kilometre Array (SKA) project development. For instance, the UK government has created the "Newton Fund Programme" which is administrated by the Royal Academy of Engineering, with the aim to develop science and innovation partnerships that promote the economic development and welfare of developing countries. In the same time, the South African government has launched the "SKA Youth into Science and Engineering project" which has awarded, since 2005 up to date, bursaries in the areas of astronomy, including PhDs, MScs and postdoctoral fellowships.

The University of Manchester, on whose site the SKA HQ is based, is developing a collaboration programme with Chinese Academy of Sciences for the exchange of scientists that will link the construction of FAST (Five hundred meter Aperture Spherical Telescope) in China with the development of the SKA project that will help China enhance its capabilities in development of key components of receivers for science observation. The extremely Low Noise Amplifiers (LNAs), Phased Array Feeds (PAF) and Analogue-to-Digital Converters (ADCs) are among those that have been identified. In addition, SKAO Office has also provided opportunities by offering secondment programme to several Member States, such as a three-year exchange programme with Japanese radio scientists, the yearly-based exchange programme with Chinese secondment on signal system modelling and outreach communications.

BOX 5. ESFRI Landmarks' current practices in industrial cooperation and innovation during the construction phase (from the survey of ESFRI Landmarks, 2015)

3. Industry as a user - the downstream business model

3.1. Various types of access to Research Infrastructures

Direct access to RIs by industrial users aiming to carry out their own experimental research seems to be low, on average less than 5% of the total available user access time. Industrial direct access is assumed to be proprietary research and therefore a fee, covering the full operational costs, has to be paid for access. But as a matter of fact it is well known that a larger – and partly hidden – involvement of industry in RIs exists – roughly 20% of the total beam time or even more, for analytical facilities – within the framework of partnerships with public (academic) users. These collaborations between industry and academic institutions via (industry-focused) research projects being conducted at many RIs occur in a kind of grey zone. In such cases issues related to IPR, "co-property" and publishing regimes are regulated in the research contract between the public and private partners, usually on the basis of the specific funding scheme – totally private funding, in-kind participation of the academic institution, collaboration in publicly granted projects – and typically there are no concerns on the RI access. It would be necessary to take this practice explicitly into account and the RIs should become a recognised partner in this type of collaboration in order to be able to identify the full real added value of the RI which should not be minimized by the funding authorities. Another element is that the RI does not have the means to check whether the results have been published in totality in the open academic literature. Fortunately, such unsatisfactory situations can sometimes lead – when the preliminary results are positive and some critical mass is reached – to the settlement of long-term collaboration between the industrial company, the facility and the laboratory acting as an intermediary.

The various types of access to RIs should be well identified, including clear and transparent charging rules and publishing policies, into:

- pure academic research (free of charges);
- industry-academic (industry-focused) research;
- programme-based cooperative research groups (industry-driven or not);
- proprietary research (at full cost).

The touchy balance between the necessity to pay for access and the requirement of scientific excellence could be summarized by the expression "the more academic is your project, the less access cost you have to pay".

The right balance between business-oriented activity / service provision and scientific collaboration is difficult to determine, and depends on each specific case. In this context the RIs should identify: (i) the actual full access costs including all services and (ii) the socio-economic impact generated by the access to the facilities. The adoption of analytical accountability practices for the facility management should indeed be encouraged in order to clarify and facilitate the elaboration of realistic and reliable operation costs. Moreover, this would also participate to the identification of hidden costs supported by the researchers' hosting institutes.

In order to improve industrial use, the transparency of access conditions to the facilities' devices, instruments and services should be improved. In particular, the various collaboration regimes should be detailed, including a catalogue of access prices and of IPR conditions for each type of access. It could be wise to explore the possibility to negotiate and grant rebates to European sectorial research centres and to technological clusters. Programme-based access open to long-term projects funded by research agencies and / or private companies could be promoted as an intermediate access mode between the strict scientific merit-based access and the confidential proprietary access. This programme-based access would be free of charge and the results would be published – with a possible embargo period. The free access would be compensated by potential royalties to the facility in case of further commercial developments. Academic users should be encouraged to inform the RIs about sponsoring by industrial clusters or other private sources when they apply for requesting access. Here again the facility could guarantee an embargo period on the results in order to let enough time to the users' partners to protect any innovation generated through the use of the facility.

The **BOX 6** provides the summary figures for the **ESFRI Landmarks' summary figures of industry access to RIs** (information extracted from a survey made by the EC in 2015).

ESFRI LANDMARKS' SUMMARY FIGURES OF INDUSTRY ACCESS TO RIS

PROPORTIONS OF TOTAL ACCESS TO THE RI (no figures for environmental facilities)

- *Basic science*: from 5% to 85% (100% for purely basic science facilities).
- *Innovation related* (involving industrial/civil service): from 10% to 100% (0% for purely basic science facilities). Analytical facilities: up to 30-40%. Health: up to 100%. SSH: up to 20%. Nuclear Energy: up to 70%.

ACCESS TO THE RI (no figures for environmental facilities)

- *Excellence-driven* (including collaborative research with academic teams): from 80% to 100%. It includes "hidden" market-driven access. Analytical facilities and nuclear energy: up to 30%. Health: up to 25%.
- *Market-driven "proprietary research"* (i.e. purely commercial access): from 0% to 35%. Analytical facilities: up to 3-4%. Health: up to 20%. Nuclear Energy: up to 35%.

ACCESS CHARGING IN PLACE FOR INDUSTRY

- *Excellence-driven collaborative research*:
    - free access for pre-competitive research;
    - institutions/industry may contribute (in kind) in return for share of novel IPR (e.g. EATRIS);
    - not for profit rates in the framework of specific agreements (e.g. agreement of ECRIN with JTI IMI and EU where IPR go to industry);
    - PPPs for access in the framework of research programmes (e.g. PPP of ESRF and ILL with CEA and French industry on micro- and nano-electronics, with funding from French authorities and EU H2020).
- *Proprietary research*: full actual cost

BOX 6. ESFRI Landmarks' summary figures of industry access to RIs (from the survey of ESFRI Landmarks, 2015)

Quality chart on access

A quality chart regarding access to the experimental facilities could be established. This chart would ensure a standard of quality that complies with the expectations of the users. In particular, this implies the setting up of access management tools and procedures in order to:

- calculate the full cost or the cost prices of all expenses linked to access (by analytical accounting or not);
- draw up quotations based on full costs or cost prices, with schedules for the projects' progress and the deliverables to be supplied;
- give access to legal support about contracts;
- forecast and monitor the requirements for the projects (equipment, human resources);
- comply with contractual undertakings (costs, timescales, management of partner complaints, etc.);
- enhance relationships with users and assess their satisfaction.

Remote control access and virtual use of the facility

The friendly access – or hands-free use – of the facility by new and non-experienced users, in particular industrial ones, should be facilitated. Specific tutorials would help in understanding the capabilities and optimize the use of the facility. When possible, the online communication system may also allow the remote user to control the whole experiment in real conditions. The purpose is here to create an avatar of the facility based on the development of a codes' system aiming at simulating experimental devices exactly similar to those available in the RI. This exact virtual replication would allow external users to test their ability to produce close results compared to those which could be obtained by the real experiment. Furthermore, this system could allow to better tune and optimize the preparation of a future experiment on the real device. The simulation system could use innovative modelling techniques such as *ab initio* codes and 3D virtual reality in order to plunge the user in near real driving conditions of the experiment as well as to guarantee the production of the first valuable "virtual" results of the future experiment. Indeed, for its part, the validation of the codes' system should be based on the results of the largest number of existing experiments. Such tools would definitely increase attractiveness of the RI for industrial users as well as virtual use.

A further range of actions for reinforcing the interaction between RIs and industrial users that will be discussed in the following sections include initiatives:

- to improve the awareness on the capabilities and opportunities available at the RIs sites, especially for SMEs;
- to create dedicated room with some "must-have" technology platforms for industrial pre-competitive research in the RIs ecosystem;
- to provide access to specifically tailored smart services;
- to make, in general, scientific results more suitable for technological innovation.

3.2. Knowledge Transfer

It is useful to re-emphasize here that the core production of RIs is scientific results but that knowledge and technology transfer should be considered as an integral part of RI's mission. Technologies developed and used by RIs have usually applications in many domains with high relevance to society. For example, accelerator science has been providing a significant contribution to innovation in medical sciences over the last 10-15 years. By making an impact on key application domains, RIs illustrate the role of fundamental research as a driver of innovation which delivers tangible benefits to mankind. The RI's technical departments have unique knowledge and skills and should collaborate with industry and investigate how their know-how can be used to satisfy industry needs. One should also emphasize that the major added value of TT / KT efforts are their impact – before money – and the creation of a new culture in the RIs and amongst their industrial users and suppliers.

Scientific results can refer, in the context of applied research, to principles and processes which are interesting for manufacturing and production systems, but still with a low technology readiness level; that is they are not "plug and play" technologies immediately ready to be transferred into the production environment. The scientific knowledge of industry needs indeed to be increased, especially in a context of fast technological progress and of "co-creation" of solutions by scientists and industry. The TT strategy of the technology push, asking research teams to help enterprises to solve their problems, has shown its limits in the two last decades. For example, at European level, the Innovation Relay Centres (IRC) network, which was set up to help companies to find external competences they need to improve their innovation capacity, has been converted into the European Enterprise Network (EEN), more focused on entrepreneurial needs. It is thus necessary to move from the paradigm of TT to the paradigm of KT. Indeed, a technology

pull approach seems to be more feasible and reliable, where industry, aware of RI capabilities and of what is carried out in the laboratories, is able to set up its own research programme and to find the right collaborations with academia and better exploit RIs capabilities. A more effective scientific awareness of industry can be achieved with dedicated KT actions. A certain amount of KT funding might be provided by specific actions supported by the EU Horizon 2020 RI programme.

As an example of dedicated KT action, see the **BOX 7** on **Knowledge Transfer Fund at CERN**, a fund introduced by the Knowledge Transfer Group to support and develop knowledge transfer activities at CERN.

KNOWLEDGE TRANSFER FUND AT CERN

The Knowledge Transfer Group introduced in 2011 a fund to support and develop knowledge transfer activities at CERN. Funding comes half from TT incomes and half from (local) public resources. In order to be considered for funding, projects should meet the following conditions:

- the project proposal must be approved by the Department Head;
- the salary cost of staff members involved in the project are covered by the Department;
- the project is based on a CERN technology;
- the IP required to execute the project is owned or co-owned by CERN and there is no conflict over the IP required to execute the project.

Projects are evaluated by the KT Fund Selection Committee (CERN Head of Finance, Procurement and Knowledge Transfer Department, chairman; all Department Heads, the KT Group and Deputy Group Leaders, the Technology Transfer and Intellectual Property Management Section Leader).

Project description includes the CERN technology on which the project is based; schedule, key milestones and organization, overall financial planning and requested budget, market potential or user community (field of application, competing technologies, identified and/or potential commercial partners, established user community). Project holders may request the support of KT experts in market analysis and to help assess the dissemination potential of the related technology. After presentation of the proposal by the coordinator the Selection Committee evaluates the proposal quality, S&T value, dissemination probability and possible impact (technology addressing key societal issues, breadth of affected public).

In 2015, six projects were currently funded in the following areas: development of an IT tool for event management; design for a radiation-resistant power convertor for LED-based emergency lighting; radiation qualification according to standard procedures for equipment aboard miniaturized satellite (CubeSat, collaboration with ESA); delivery and testing of a new electron gun designed as injector for an Electron Beam Ion Source (used for second generation ion beam therapy facilities); improving performances of contactless laser based distance measurement techniques, protection of cryogenic equipment from an accidental overpressure scenario.

BOX 7. Knowledge Transfer Fund at CERN

3.3 Open innovation and co-creation

The risk and cost of early research is extremely high. Some research challenges are so big that companies cannot afford to tackle them alone. Making available to companies – including SMEs – new room around RIs, dedicated to pre-competitive research programmes, where the possibility to exploit the RIs technological resources is more effective and where scientists and engineers work together in the same place on common objectives, would increase KT and the exchange of competences. The aim is to join (PhD) research, technology platform and industry core business in a sort of a shift from TT to "co-creation" in this innovation ecosystem. It is important that scientific researchers and industrial technologists first identify common objectives – to build a shared vision – and then work together in the same place. Staff trained in this scientific environment will more easily move to industry with the effect to increase the perception inside industry of what is carried out in the RI laboratories. A space where customized programmes based on bilateral contracts can be implemented is more effective than a consortium approach. Moreover, the possibility for an enterprise to be hosted in such an environment to carry out its research programme, makes the enterprise itself more competitive when applying to public funding; more generally this makes the RI ecosystem more attractive to industry.

As an example of open innovation, see the **BOX 8** on **Open innovation at IMEC**, which describes the precompetitive space created around the RI where "must-have technological platforms" are offered to industry in a working mode.

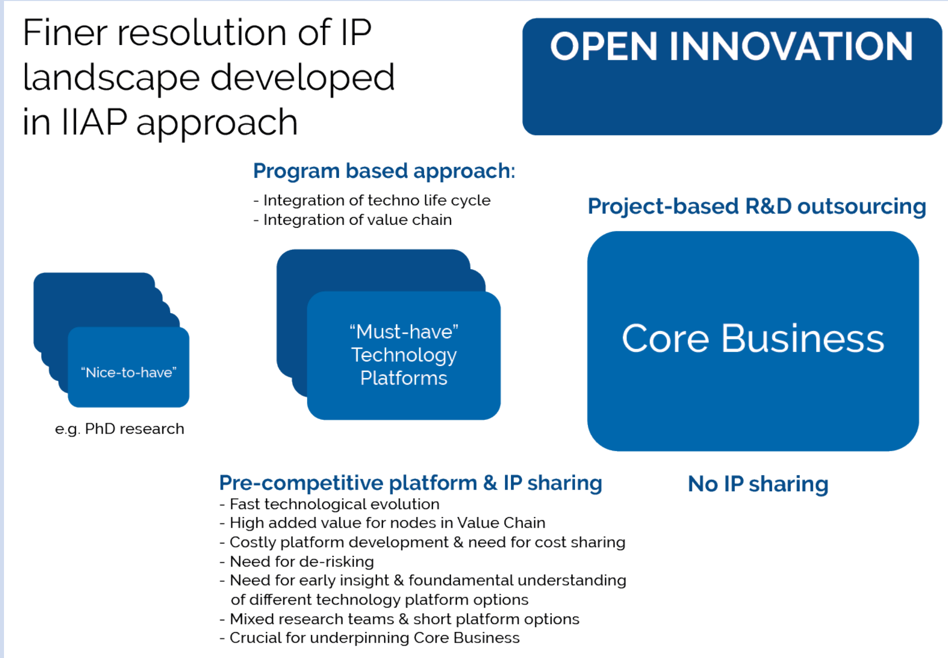
OPEN INNOVATION AT IMEC

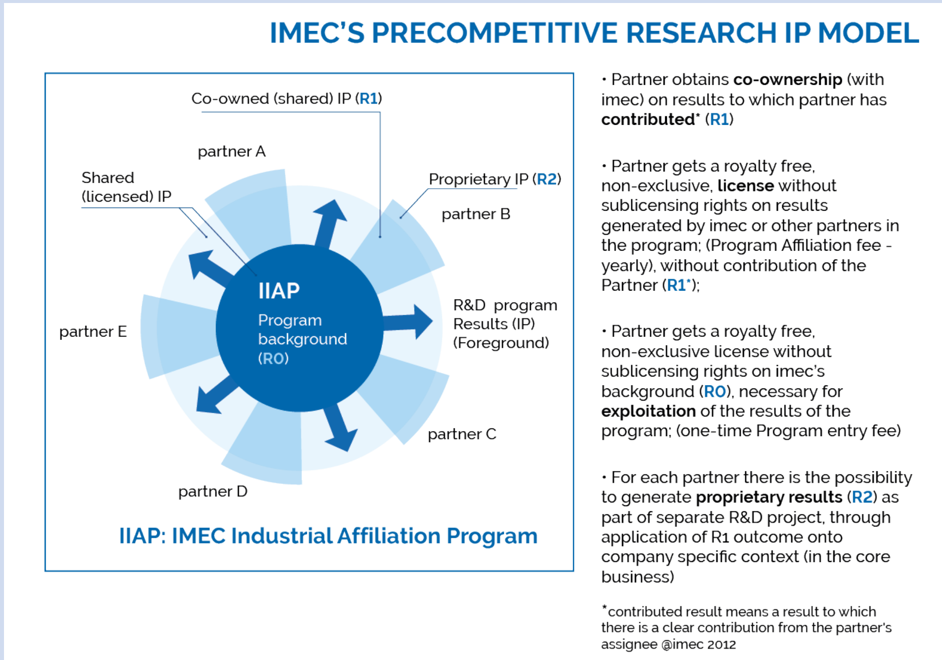
IMEC's experience is an example of a new "precompetitive space" created around the RI where "must-have technological platforms" are offered to industry in a working mode. Effectiveness is firstly due to the fact to be in the same place and work together on shared objectives. The aim is to join: PhD research; technology platforms and core business. IMEC acts as a service not for problem solving or TT stuffs but for research programmes, properly funded.

The multiple partner programmes gather technology leaders across the value chain to jointly perform pre-competitive research. These partners share expertise and lower risk and cost of advanced research to accelerate innovation on a generic level.

For companies that need more specific support or a dedicated solution, or when companies want to use IMEC's advanced infrastructure for private research, IMEC also offers a bilateral collaboration mode, involving just the company and IMEC. In the bilateral customized Industrial Affiliation Programmes (IIAP) the industrial partners rotate around IMEC rather than using a consortium approach. A specific precompetitive research IP model is used; noticeable is the power of using a unique IP fingerprint.

Also IMEC has "development on demand" but in such a case industry pays the full cost. Mainly big industries are involved, but also SMEs have been attracted by means of an enterprises network.





BOX 8. Open innovation at IMEC

Global open innovation

Several aspects of innovation have been explored by the Group of Senior Officials (GSO) on Global Research Infrastructures (GRIs), focusing on the establishment of innovation hubs around GRIs, on GRIs as a source of knowledge for innovation, and on the intellectual property (IP) issues and their overall value. The Group identified innovation opportunities at each stage of the RI lifecycle as reported in the GSO Report 2017[4] (see **BOX 9** on **Global open innovation opportunities and challenges across GRI lifecycle**).

4. GSO Report 2017
https://ec.europa.eu/research/infrastructures/pdf/gso_progress_report_2017.pdf#view=fit&pagemode=none

GLOBAL OPEN INNOVATION OPPORTUNITIES AND CHALLENGES ACROSS THE GRI LIFECYCLE

LIFECYCLE STAGE	CHALLENGES AND OPPORTUNITIES
Development Stage	**Innovation opportunities, outlined at conceptual design study, in the international collaborative effort that defines the terms of the GRI. Innovation in the governance and management of GRI type. Innovation impact on the foreseeable in-kind contribution and its management adaptation to all participating Countries/Institutions. Innovation in the legal/financial tools to be adopted to establish the GRI.**
	Further identification of the types of innovation that could occur and the magnitude of activity, e.g. identifying novel technical developments required and potential uses of the data.
Design Stage	**Innovation through co-design with industry, public services, and stakeholders for the technical design study, cost-book and in-kind contribution selection and tender.**
	Build and plan the innovation processes for this and all subsequent stages in the RI lifecycle. Communicate with stakeholders to manage expectations on what can be delivered for all partners e.g. Intellectual Property in the RI team, academic labs or industry that arises from R&D on new technologies to enable RI construction.
Implementation Stage	**Innovation at first-contact level with the industry and services involved in the construction and beneficiaries, through tender, of the main part of the construction budget. Development and co-design by the GRI and industry/services of the innovative technologies needed for the implementation. Policy for co-ownership of IP by the GRI and partners of**

	the economy and/or educational sector. Innovation issued by IP share of the co-design and prototyping. Set up process tools for managing and monitoring innovation activities e.g. capturing the potential for companies delivering RI components for upskilling and delivery of higher quality products and services to other clients.
Operations Stage	**Innovation from operation methodologies, co-development of services to support operation. Research data management policy and its openness towards innovation-oriented usage. Impact on innovation by research results.** Monitor innovation activities and revise the innovation plan to reflect any changes e.g. identifying the results flowing from the RI and how these are exploited by companies or establishing a data management centre that could potentially support other activities.
Termination Stage	**Innovation in the long term conservation of data and access policy.** Ensure that any IP is distributed to stakeholders or released to collaborators for appropriate returns to the RI or successor organisations e.g. put arrangements in place to monitor ongoing returns on innovation investment by any successor organisation or select a stakeholder organisation to monitor this.
Legacy Stage	Carry out a whole lifetime study after the RI is decommissioned. An example of innovation at this stage could be that after closure the location remains an innovation hub based on the cluster built up during the operations stage.

BOX 9. Global open innovation opportunities and challenges across GRI lifecycle (adapted from the GSO Report 2017)

3.4. Specific services tailored for industry wand training

Another KT action, aiming to downscale the innovation of processes and manufactures, could be the implementation of services tailored for industry. A clear example can be taken from the field of new materials, where companies are used to run technological proofs – braking, bending, hardness, corrosion, extreme conditions – all related to macro properties and there is a lack in understanding the behaviours at the micro- / nano- or molecular scale. A smart access to some characterization techniques, simulation and nanoscale synthesis could put into contact SMEs with RI capabilities and change the innovation approach from one of trial and error to one of cause and effect. The critical mass of RIs, the ensemble of state of the art techniques they provide, joined with the possibility to create networks, like in the EU Integrating Activities programmes, make RIs the natural candidate to promote this kind of cultural change in the innovation approaches, when compared with conventional laboratories.

Dissemination and stimulation actions should be carried out in close connection with sectorial industrial organisations and Registered Training Organisations (RTOs), with the support of the EU. Training of a new generation of engineers in the industry, more aware about science and RIs, as well as of a new generation of researcher, more receptive to IPR issues and industry needs, and mobility from academia to industry, are two essential blocks of the KT approach, that is, new dedicated funds for KT, new rooms, new services are the methods and the means, but people, the human factor, is the core content. Training and mobility of technicians and engineers is the most effective way to transfer efficiently scientific results and knowledge to the innovation and production system.

The use of Marie Curie fellowships "Industry-academia pathways and partnerships" by RIs should be stimulated.

In brief:

(i) Before transferring a technology it must be created, possibly in an efficient ecosystem upholding the ethos of "people working together in the same place on shared problems with a comparable motivation".

(ii) The scientific knowledge and the understanding by industry of what is carried out in RI laboratories needs to be increased, especially in a context of fast technological progress where the "co-creation" of solutions by scientists and industry and open innovation are increasingly required.

(iii) The best vector to transfer knowledge from the scientific communities to the production system is the human capital.

(iv) The unique innovation ecosystems existing around RIs are well suited environments to implement such a model. Therefore, in order to optimize the impact of the operation of RIs on industry the co-creation of new technologies and new solutions as well as the implementation of an efficient brain-drain from academia towards industry and vice versa should be stimulated more effectively, possibly in a structural way.

3.5. Protection of the innovation results

A RI must develop an intellectual protection policy for its own research results, technology developments and know-how in order to place them at the service of the competitiveness of European enterprises or academics. It actively and proactively promotes its intellectual property – transfer of licenses – in accordance with the contributions of each partner and with a sustainable partnership policy with the economic world. In this respect, it makes the efforts needed to have at its disposal a complete and up-to-date vision of its portfolio of patents and licences.

Industrial and scientific users of RIs have usually very different needs in joint research projects which may create conflicts of interests – e.g. in the exploitation and / or publication of the results. These projects are usually supported by public funding programmes and often co-funded by industry. IPR issues are a very important part of this cooperation, which should be tackled, and there should be mechanisms to ensure that industry's IPRs can be protected as an incentive for industry to invest in research cooperation and to commercialize the results when possible. Industrial partners carry out their research in RIs also for validation and standardization and to get references. This type of cooperation is generally based on contract research agreements where the costs are mainly covered by industry, which usually get exclusive licenses or ownership of IPRs in return for payment.

On the other hand, the inventions created by scientific users of RIs and the staff of RIs should also have protection and commercialization processes in place including e.g. TT and IPR funding services. The most common methods to commercialize patents based on academic research are licensing to established companies or to spin-offs. The decision to commercialize patents via spin-off creations is influenced by the capability of the inventors to recognize the commercial potential of their results and motivation to exploit inventions through entrepreneurial efforts whereas the decision to commercialize patents via licensing is made by scientists themselves, industry, and TT Offices (TTOs) case by case. More than half of the RIs have TTOs in place and in some cases these are organized as separate companies. However, only very few RIs have an active policy to go on the markets for a TT or to invest in business development based on their inventions. Thus, better business-awareness of RIs including the skills for assessing, protecting and commercializing inventions and, where appropriate, the installation of a TTO, should be promoted.

A series of actions should be initiated in order to improve the efficiency of the IPR policies. Case studies to investigate different IPR scenarios relating to various IP matters – patent, copyright, database rights – should be launched. Instead of precipitate filing of patent applications based on early conceptual discussions, the initial and early process should make use of confidentiality-driven tools such as Non-Disclosure Agreements (NDAs). This would definitely improve the efficiency of the RI-Industry collaborations. The originator of a technical solution or aspects of such a solution will still wish to be recognised as such, so there will be a need to record discussions and, importantly, the related idea generation under NDAs. Alongside contribution goes ownership claims; it is commonplace that organisations own their employees' inventions, and therefore require that such are reported when they emerge. And finally the NDAs must be designed in such a manner that both the industry and RI perspectives are included. This will have to take place on a case to case basis, as collaborations and their subject matter vary from sector to sector.

Greater transparency could be provided by standard model agreements: (i) cost and benefit / risk-sharing schemes and (ii) e.g., a predetermined revenue stream could flow back to the RI only in cases where substantial revenue – to be determined on a case by case basis – is created by industry based on RI resources. Better business-awareness

of RIs concerning the skills and resources of assessing, protecting and commercialization of inventions should also be promoted. Active innovation and business oriented policy in RIs, including professional TT and KT services and IPR management, would improve industrial usage of RIs and commercialization of academic inventions. RIs should to a greater degree than currently consider implementing less substantial upfront payments for licenses on know-how, patent, database, and copyright coupled with reasonable royalty rates, as there are indications that such practice reduces barriers for TT in RI-Industry collaborations.

As examples, see the **BOX 10** on **Cases of licensing strategies and RI-Industry cooperation policies**. In particular, the pros and cons of the US Department of Energy (DOE) approach – for the RI, for the user – should be carefully considered. The Non-proprietary User Agreement required by the DOE for getting access to its facilities – e.g. at Berkeley National Labs – provides that all user parents' organisations must accept to give the US Government a part of the intellectual property on the products that are analysed at the National Laboratories[5]. For example, more than 400 institutions have signed at BNL, which is leading to a heavy bureaucracy for the RI management[6].

5. Access to High Technology User Facilities at DOE National Laboratories https://energy.gov/gc/access-high-technology-user-facilities-doe-national-laboratories
6. User agreements at BNL https://als.lbl.gov/user-agreements/

CASES OF LICENSING STRATEGIES AND RI-INDUSTRY COOPERATION POLICIES

The RIs – and research centers and universities – have very different types of licensing strategies, access and cooperation policies for industry from exclusion of industrial cooperation to major commercial success stories. The following cases illustrate this very clearly.

COHEN-BOYER BASIC GENE-SPLICING TECHNOLOGY INVENTIONS AT STANFORD UNIVERSITY

This is a very famous licensing case resulting over $250 million in royalty revenue for the Stanford University. University offered non-exclusive licenses with small upfront licensing fees of about $10,000, and small-percentage running royalties on any products that were developed using the technology. The small upfront licensing fee mitigates the barrier to sign up, since the companies had to pay only when they got products in the market.

THE SURVEY OF HEALTH, AGEING AND RETIREMENT IN EUROPE (SHARE)

SHARE became the first European Research Infrastructure Consortium (ERIC) in 2011 and it is a multidisciplinary and cross-national panel database of micro data on health, socio-economic status and social and family networks of tens of thousands of individuals. SHARE is strongly focused on the use of the database for scientific purposes, and does not encourage any commercial exploitation (see: http://www.share-project.org/data-access-documentation/research-data-center-data-access.html). However the scientific community is actually not the only category of users: public authorities/policy makers are also making use of the data. Pending due consideration of ethics issues and relevant privacy laws, the use of appropriate data or data products by the private sector would increase the impact of the infrastructure.

THE PARTNERSHIP FOR ADVANCED COMPUTING IN EUROPE (PRACE)

PRACE "Open Research Model" allows European companies access to world-class high performance computing resources and services in order to increase their competitiveness by reducing the time-to-market, improving reliability and safety of their products, and developing innovative industrial processes. In this model users may only use the facilities and services provided by the infrastructure for basic research and development purposes. The condition associated with this free access for the industrial user is to publish all results obtained at the end of the grant period. In addition there are some other conditions that apply to companies. The companies will get access to PRACE resources free of charge for one-year period.

ETH ZURICH

ETH has an advanced and active cooperation policy with industry. ETH has very high level technology platforms and competence centers which attract industry to support and fund cooperation projects. ETH technology transfer office helps the companies to find out the best practical solutions and draw up relevant cooperation agreements. ETH also supports company founders with its Pioneer Fellowships which offers opportunities to develop research in Innovation and Entrepreneurship Labs with external coaches and industry representatives. This encourages the formation of spin-offs.

US DEPARTMENT OF ENERGY (DOE)

The US Department of Energy (DOE) has developed various types of agreements for use at all DOE National Laboratories with approved designated user facilities. In particular, for commercial research, the user can choose the Proprietary User Agreement with which he pays the full cost for use of specialized laboratory equipment and, with limited exceptions, retains ownership of the technical data generated, as well as the rights to any new inventions. For non-commercial projects, such as basic science research, researchers must use a Non-proprietary User Agreement under which the user pays its own costs of the research with the DOE laboratory, may access specialized laboratory equipment and collaborate with laboratory scientists. The non-proprietary user and the National Laboratory retain title to their own inventions and research data generated under non-proprietary research is made public. But in case of further industrial developments, the non-proprietary agreement guarantees the DOE laboratory some ownership rights to any applications that would result. For more information, see Footnotes 5 and 6.

BOX 10. Cases of licensing strategies and RI-Industry cooperation policies

The **BOX 11** provides miscellaneous examples of **ESFRI Landmarks' current practices in industrial cooperation and innovation**, as extracted from a survey of ESFRI Landmarks made by the EC in 2015.

ESFRI LANDMARKS' CURRENT PRACTICES IN INDUSTRIAL COOPERATION AND INNOVATION

EMSO PLANS TO DEVELOP ITS POTENTIAL FOR INNOVATION

While many of the deep sea observatory projects have typically focussed on the science drivers behind ocean observation, it is increasingly important that commercial contributions to promising areas are fully developed. EMSO has undertaken a structured approach to engage with the industrial community interested in ocean observation systems and support the development of **economic clusters of innovation***. A major effort will be dedicated to identify and set up activities to increase the potential for innovation of EMSO technological output and thus contribute to increase the innovation potential of the EMSO observatories. Therefore part of the EMSODEV EU project work (under INFRADEV3) will be focused on: (i) assessing market applications and commercialisation opportunities for the generic instrumentation module (EGIM) and associated software package in areas like ocean energy, sea bed mining and marine knowledge; (ii) identifying and implementing products and services relating to the EGIM in niche sectors with a high potential to impact in areas of innovation relating to the EGIM; (iii) enhancing existing networking with industries (including SME clusters across Europe) to facilitate their involvement as partners of the RIs for technological developments; and (iv) developing customised services for industry and SMEs and disseminating research outcomes and TT with a particular focus on industry and SMEs.

* Economic clusters of innovation have been defined as "geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions that compete but also collaborate". Knowledge-based industries develop very successfully in regional clusters, which facilitate knowledge exchange and generate a critical mass of skills that complement one another. Geographical proximity (in a European context) between research organisations, investors and companies can produce networks that lead to new business ideas and the foundation of new enterprises.

EURO ARGO CONTRIBUTES TO THE GLOBAL COMPETITIVENESS OF EUROPEAN MANUFACTURERS OF FLOAT AND MARINE EQUIPMENT

Argo float industrial production and commercialization is done in Europe by two SMEs. EURO-ARGO contributes to the consolidation and to the strengthening of the global competitiveness of European manufacturers in the highly aggressive field of innovation related to floats and marine equipment. The increase of the European market (thanks to EURO-ARGO and Copernicus), new requirements (e.g. new floats, new sensors) as well as the continuous development of Argo in Japan and Australia and in emerging countries (China, India), open new market perspectives for European SME's. There is also a large innovation potential for specialized SMEs for the development of miniaturized, smart and cheap sensors to be embarked on floats or other autonomous vehicles.

IAGOS COOPERATES WITH SMES AND BIG AIRLINE COMPANIES

Several SMEs have been involved, both in the conceptual phase and in the preparatory phase of the RI. These companies are involved in the design of the aircraft modification, the manufacturing of the instrumentation and in the operational concept in compliance with European and international regulations for aviation. Applied schemes for selecting appropriate partners were direct cooperation as project beneficiaries and subcontracting via calls for tender. The involvement of airlines in the project as supplier of transportation capacity and technical support was achieved on the basis of individual negotiations and by direct involvement as full project partners. Currently three large European airlines and two airline companies from outside Europe are involved in support of the RI. Negotiations with other airlines from Europe and other countries are ongoing in order to extend coverage.

INDUSTRY AND FARMERS ARE USING ICOS DATA AND SERVICES

The most important mode of access to ICOS by industry will be through data and knowledge produced on greenhouse gases (GHG). Regional GHG budgets will provide important information for planning and verifying the decarbonation of the European industries, particularly in the energy and the transport sector. While data from pre-ICOS networks have mainly been used for early stage basic research, a stepwise transition to knowledge products is expected. They will be used for e.g.: (i) verification of inventories or reduction efforts; (ii) regional planning and scenarios on transport or energy production;

(iii) life-cycle assessments of products in the food and bioenergy sector; and (iv) decision support systems for GHG mitigation actions. The data provided by the ICOS ecosystem observational network are already used in several consultancy projects for the food industry including the application of no-till agriculture and they assess its effects on GHG balances for environmentally friendly farmers' cooperation. Agricultural practice and yield parameters are evaluated in order to develop a support system for climate-friendly agriculture. It is expected that new young and innovative SMEs will emerge during the next decade that will develop and apply these knowledge products based on ICOS RI data products for consulting industries as well as the public sector.

LIFEWATCH WILL OPERATE COMMERCIAL USER REQUESTS VIA A SPIN-OFF COMPANY

Cooperation with industry is possible in three modes: (i) as supplier, legally based on a supply contract; (ii) as co-developer, legally framed in a project agreement with license agreements; and (iii) as user, either for fundamental research competing with others, or for commercial activities closely related to LIFEWATCH, provided they do not jeopardize the achievement of its primary tasks. A separate legal entity (commercial spin-off company) will operate these user requests on its own risk.

THE MULTIFACETED IMPACT OF BBMRI ON INNOVATION IN HEALTH AND MEDICINE

- Current knowledge production in health and medicine which is largely based on bio-samples and data by integrating European biobanks to provide access to a unique resource for research.
- Health research using biomolecular data is essential for the development of personalised medicine.
- Biobanks, which are essential for understanding interactions between genes, environmental factors and lifestyles.
- Patients/donors, who know that their own tissues, samples and personal data can yield discoveries and advances in medicine, diagnostics, and therapies (most of them are willing to donate to research for the benefit of current and future patients for reasons of solidarity).

- Cross-sector collaboration (including the pharmaceutical, diagnostics, and biobanking sectors) for which it is necessary to make the most of the current knowledge in drug development and data.
- Authentication, characterisation, stable storage and supply of biomolecular samples, each of which is a major contribution to the knowledge-based bio-economy.
- Research and market development for the life sciences and biotechnology applications, which relies on access to high quality biological samples.

EATRIS SUPPORTS PHARMACEUTICAL AND BIOTECH INDUSTRIES AND MEDICINE DEVELOPMENT

EATRIS has two primary values for the pharmaceutical and biotech industries (including medical device manufacturers). Firstly, industry has access to highly capital intensive facilities and expertise that are otherwise out of reach for companies, especially SMEs. Secondly, the result of matching Europe's top infrastructure and translational expertise to the best research projects will support rejuvenation of the biopharmaceutical pipeline with more high promise, "derisked" clinical phase projects. Academic users can access EATRIS to get support in the advancement of their novel drug (target) or diagnostic, so that the IP can be matured to a point of being ready for transfer to industry. In medicine development, a great deal of capital-intensive applied research is necessary to bring a new drug to a point in which industry becomes interested. EATRIS is focused on supporting in bridging that gap to industry.

ECRIN: INNOVATION RELATED ACCESS REPRESENTS 95% OF THE TOTAL USE

Innovation related access involving industrial/civil services represents 95% of the total use (primary involvement in managing independent clinical trials for the benefit of health and healthcare systems). Access provision for industrial users:

- "hidden" market-driven (in collaborative research with academic teams): trial sponsored by academic institutions but supported by industry funding. IPR goes to the academic sponsor;
- market-driven "proprietary research" (i.e. purely commercial access): trial sponsored by industry but funded by IMI (the Joint Technology Initiative

"Innovative Medicines Initiative", a PPP between industry represented by EFPIA, the European Federation of Pharmaceutical Industries and Associations, and the EC). IPR goes to the industry. Half of the budget comes from the EU and the second half in the form of in-kind contributions from EFPIA, its member companies and several other companies. The EU funding supports the participation of the "public" partners in IMI projects, i.e. universities, small biotech companies, patient groups, regulators, etc.

As regards access charging in place for industry, the ECRIN statutes consider two cost models: (i) a non-economic model, where services are provided at not-for-profit rates, and (ii) an economic model, with services provided at market rates. Model (ii) should not exceed 10-20% of activity. Academic as well as IMI projects are run under model (i).

HOW INFRAFRONTIER COOPERATES WITH INDUSTRY

INFRAFRONTIER partners are engaged in a number of joint development projects with manufacturers of research instrumentation or animal cages. These collaborations facilitate end-user driven developments of innovative new instruments that are also validated in a user environment. This ultimately leads to superior end products and translates into increased market shares of the industrial development partners. A large number of industry partners act as suppliers, but also as innovation partners in the development of novel research instrumentation.

Various modes are used to facilitate industry access. These can be material transfer agreements or specific licensing agreements between depositors of mouse mutant lines and requestors or other agreements between consortia and third parties to facilitate industry access to certain resource collections such as EUCOMM mouse mutant resources. Furthermore, access can be facilitated by bilateral cooperation agreements.

INSTRUCT DEVELOPS ACTIVELY ITS COOPERATION WITH INDUSTRIAL PARTNERS

Structural biology is a fully embedded part of the drug discovery process and access to INSTRUCT infrastructure is open to industry through the same access procedure as academic users for precompetitive research where results will be published. Extensive collaborations already exist between INSTRUCT Centres and several European companies, e.g. in the area of structural vaccinology; in membrane protein structure; and more generally in the development of new instrumentation, analytical methods and software.

INSTRUCT has setup an Industry Committee to promote bridges with industrial partners and to implement the industry outreach programme. INSTRUCT Centres are active in brokering investments through extensive collaboration with the European structural biology community. These Centres have been successful beneficiaries of early access to novel and emerging methods and approaches that have enhanced the RI itself. INSTRUCT fosters active participation of representatives from industry in workshops and training events, some of which are co-organised with industry. Additional resources from the private sector result from INSTRUCT Centres being made available for beta testing of new equipment, new approaches using new methods or for new products. This cooperation strengthens the bonds between academic and research organizations with the industrial sector.

ELIXIR, A BIG CONSUMER OF HPC

It is estimated that in Europe alone, cloud computing can hugely contribute to EU GDP in the coming decade. The life science sector as a consumer of HPC is already high and set to increase further. Collectively the investments made by Member States in the data centres and cloud services run by ELIXIR partners are extensive. ELIXIR will provide a form to engage collectively with the HPC community, especially the ETP4HPC, which can support the long-term stimulation of this industry sector further. ELIXIR is also collaborating directly with HPC providers on pilot research projects, e.g. collaborating on a short project to develop a virtual machine for training resources that could be deployed across the ELIXIR infrastructure.

PRACE FOSTERS PARTNERSHIPS WITH INDUSTRY

Since the inception of its open R&D offer, PRACE (the partnership for advanced computing in Europe) has fostered collaboration and TT & KT between academia and industry. Through implementation projects supported by the EC, PRACE is proposing high-value services for code enabling, training, user support to industry, allowing companies to benefit from the expertise gathered by PRACE partners. PRACE launched a specific (successful) initiative called SHAPE (*SME HPC Adoption Programme in Europe*) for supporting European SMEs in the use of HPC and advanced numerical simulation, in order to demonstrate that HPC enables SMEs to become more innovative and competitive.

PRACE has set up an *Industrial Advisory Committee* composed of high-level representatives from major European industrial sectors in order to advise the RI in the development of new services towards larger usage of HPC and data services by industry. In addition, a User Forum provides feedback on the effectiveness of the services and suggests service development.

Several examples show how industry investment is attracted: (i) PRACE is running a PCP on HPC on the provision of R&D services that seek solutions for Whole-System Design for Energy Efficient HPC; (ii) PRACE supports works together with industry to enable their codes and improve their competiveness; and (iii) as already mentioned, the SHAPE initiative supports the implementation of complete projects, including computation, for SMEs around Europe, where the latter “invest” their engineers and experts to co-develop the projects.

JHR, FAIR AND SPIRAL2 DEVELOP SERVICES FOR NUCLEAR MEDICINE AND RADIOBIOLOGY APPLICATIONS

JHR (the Jules Horowitz Reactor) will also be used for nuclear medicine. It will supply hospitals with short-lived radioelements used in medical imaging units for diagnostic purposes. These radioelements, such as the Molybdenum99-Technetium-99m, have a limited lifetime of a few hours. They therefore need to be produced on an ongoing basis. The JHR will contribute to 25% of the today European production of Molybdenum 99 on a yearly average or even up to 50% in a peak situation.

FAIR will continue the investigation initiated by its host organisation (*GSI Helmholtzzentrum für Schwerionenforschung*) of health issues with its biophysics research (e.g. ion-beam radiotherapy has been used by GSI to treat several hundred patients).

At GANIL a R&D program for production of innovative radio-pharmaceuticals with the SPIRAL2 Phase 1 beams was initiated with academic and industrial partners. A new program of industrial applications with a direct use of beams and available facilities as well as technical developments, like new ion-sources and beam diagnostic systems at the GANIL-SPIRAL2 facility is currently under development. SPIRAL2 will contribute to research on radiobiology, hadron and isotope therapy against cancer. A part of the beam time of the SPIRAL2 accelerator and human resources will be dedicated to this research.

ESRF AND ILL DEVELOP THEIR INDUSTRIAL ACTIVITIES

The ESRF Business Development Office (BDO) offers industry a privileged and practical access both to beamlines and expertise, enabling them to help solve process problems, reduce product-to-market times and enhance R&D programmes. A substantial part of the ESRF's industrial activity comes from pharmaceutical companies that use the macromolecular crystallography beamlines for drug design. Other beamlines are used to carry out experiments for cosmetics, food products, plastics, oil production, metallurgy and other areas such as microelectronics. The ESRF has established partnerships with neighbouring institutes (including the ILL) that extend services to companies and research laboratories beyond the simple access to X-ray beam time: the Partnership for Structural Biology, the Partnership for Soft Condensed Matter, and the IRT NanoElec make characterisation tools available that complement the X-ray instruments. The partnership with NanoElec Large-Scale Facilities Characterisation Platform (including French industry), ILL and CEA enables the ESRF to work with European electronics' industries and sets the scene for routine use of nanoscale X-ray beams for commercial R&I. Similar partnerships dealing with problems and questions related to environment, energy, metallurgy and cultural heritage are being developed.

The ILL's Industry Liaison group provides a single and specialised point of contact for any potential user from industry and services. Industrial clients may choose specific modes of access, considering the level of confidentiality they require: proprietary research, academic research service and a combination of proprietary and academic access “Cooperative solutions for industry” – an option ensuring that the finest academic research matches the requirements of industrial innovation. The resources invested by the partners vary with the characteristics of the project, as does the level of access to the facilities and the distribution of IPR income.

KNOWLEDGE TRANSFER WITH CESSDA TRAINING...

This service provides customised guidance and training workshops on research data management and digital preservation in conjunction with other recognised CESSDA organisations and experts. Support is provided in the area of: (i) data management planning for researchers, research projects, and research centres in the social sciences; (ii) the importance of sharing publicly-funded research data and meeting funder requirements on data management, preservation, and re-use; (iii) best practice on obtaining consent for re-use, data copyright and the use of existing data sources confidentiality and anonymisation, documentation and data enhancement, methods of data sharing, file formats, physical and digital data storage; and (iv) support for long-term preservation and dissemination of research data. Individual consultations and collaboration with researchers and archivists on these topics is also offered. *CESSDA Training* events regularly include the following topics: introduction to Research Data Management for Social Scientists; first steps towards digital preservation; teaching an introductory workshop in digital preservation (train the trainers).

...AND WITH CLARIN'S KNOWLEDGE SHARING INFRASTRUCTURE

The technical infrastructure of CLARIN enables integrated and sustainable access to a vast amount of European collections of digital language data in the form of text, audio, video and other modalities, as well as to advanced tools to explore, exploit, analyse, enrich or combine them. CLARIN operates in parallel a so-called *Knowledge Sharing Infrastructure*, in order to ensure KT between all parties: providers ⟷ users, users ⟷ users, and providers ⟷ providers. Main instruments are the creation of (possibly virtual) knowledge centres, mobility schemes and training and awareness activities. These activities may easily lead to innovation in the future when services become more advanced. Similarly, the knowledge present in CLARIN will become more and more relevant for industry.

ESS SOCIAL HELPS POLICY MAKING

ESS is used to provide both direct evidence and contextual evidence across a range of non-academic bodies. ESS data is cited in a number of UK government reports from a series of departments including e.g. Work and Pension, and Business, Innovation and Skills. ESS data has been used directly by the UK Office of National Statistics to develop its wellbeing programme; by the OECD to study social outcomes of learning; by think tanks including the New Economics Foundation (NEF), the Intergenerational Foundation and AgeUK; these have led to further outputs which have included government reports, for example on work and the family.

Moreover, research generated by academics using ESS has been used to influence policy and practice in various government departments and offices. ESS has helped inform the work of other surveys both in the UK and in Europe in terms of its methodology. These include Understanding Society, the European Values Survey and the International Social Survey Programme. ESS data and methodology are used in academic teaching in many countries. In addition, the ESS has a programme of KT directly with policy makers and has held seminars at the European Parliament, Italian Parliament and OECD amongst other locations.

SHARE'S IMPACT ON INNOVATION ACTIVITIES

SHARE has developed innovative software for electronic survey operations, including designing questionnaires, translating them, administering them to respondents, monitoring fieldwork, and creating the data bases. Most of such innovation was carried out by a SME company. This company has been involved in the SHARE study since its inception and has designed a uniquely efficient centralised workflow for the support of large, multilingual longitudinal surveys. SHARE has developed the health measurement in large population surveys by introducing physical performance measures (grip strength, chair stand, peak flow) and dried blood spot sampling using devices and materials from SME companies. Train the Trainer Session are organised in order to train survey agencies before the waves start on innovations in the questionnaire. Young researchers in all SHARE countries are trained in database management skills. In addition user-training workshops are offered to researchers who want to analyse the data.

DARIAH'S ESTIMATES OF FUTURE USE AND COOPERATION WITH INDUSTRY AND CULTURAL INSTITUTIONS

Innovation related access involving industrial/civil services is estimated at about 1/5 of the total use of DARIAH in the coming years. It will occur mainly through the cultural and creative industries with a strong overlap with local academic units and less frequently policy makers or specialised industries such as commercial archaeological or historical survey units.

"Industrial" partnerships will mainly be established with the cultural industries like museum collections or archival holdings. There is a need to work closely together with them on the co-development of the digital transformation of the humanities. The digital transformation also means that traditional boundaries between these institutions are disappearing. DARIAH is therefore a RI by researchers for researchers who would like to participate in re-directing the research environment of arts and humanities together with the cultural institutions.

BOX 11. ESFRI Landmarks' current practices in industrial cooperation and innovation (from the survey of ESFRI Landmarks, 2015)

4. Data policies and e-Infrastructures[7]

7. This chapter has been established in collaboration with e-IRG (the e-Infrastructure Reflection Group), following a workshop organised in September 2015 with several e-Infrastructures

4.1. The innovation potential in research data

RIs, such as the projects on the ESFRI Roadmap, produce and are dependent on rapidly increasing amounts of data. Storing, sharing and re-using such data from RIs can stimulate the creation of new products and services, new companies and jobs. New trade flows might develop, and the competitiveness of regions and nations can be improved. The amount of data created by RIs is exploding, and the ICT resources and e-Infrastructures for accessing and using data are developing extremely rapidly. This lays the ground for significant impact on innovation also on a rather short time scale. However, the exploitation of the innovation potential inherent in RI data is still only an emerging process. The Data Harvest report[8], presented by the European branch of **The Research Data Alliance** (RDA[9], see the **BOX 12**) in 2014 elaborates and presents concrete figures on how innovation based on sharing research data can yield knowledge, jobs and growth in Europe. Here, RDA´s vision is of researchers and innovators openly sharing data across technologies, disciplines and countries to address the grand challenges of society.

From both the RDA reports and other discussions, it is obvious that research data represents significant financial assets and business opportunities. It is also obvious that it is often still unclear how and on what conditions actors outside academia, especially commercial actors, can use such data due to IP and privacy issues. The Digital Single Market (DSM) strategy includes new components to tackle these questions and it is foreseen that the solutions presented can significantly facilitate the exploitation of the market potential in research data already during the H2020 programme.

8. Data Harvest report
https://rd-alliance.org/data-harvest-report-sharing-data-knowledge-jobs-and-growth.html

9. The Research data Alliance (RDA)
https://rd-alliance.org/

THE RESEARCH DATA ALLIANCE (RDA)

The RDA's main emphasis is to ease discovery, access and use of research data by world-wide scientists regardless of which institute or agency is collecting and distributing the data. Ensuring proper capture, accessibility and availability of the data is the task of the individual institutes and agencies. The RDA is focusing on developing joint capabilities for querying, accessing and sharing data across international research data archive systems. Instead of promoting standards which drive common methods for collecting and describing research data across the international scientific communities, the RDA concentrates on sharing the research data from diverse standards and collection methods. Such an approach will better support the long-term goal of easing data sharing across economical stakeholders, scientific institutes and research agencies.

BOX 12. The Research Data Alliance (RDA)

4.2. The need for data management and metadata

For research and society to take full benefit of the major investments in RIs, the data connected to them needs to be made easily available and re-usable. Also, the availability of data needs to be complemented with aspects of discoverability, quality and adherence to standards, and the data frameworks must be open and cover wide spans to enable new, potentially unexpected exploitation. The data needs to be managed, stored and preserved in a cost-efficient and effective manner, with appropriate quality and safety assurances, and the underlying data infrastructures need to be set up in sustainable settings. Here, with the appropriate financial support mechanisms, e-Infrastructures can provide the versatile services and tools needed for both data management and access, but the development of such "transversal" infrastructures must be complemented with specific efforts on RI data policies and coordination.

To promote the re-use of research data it is now common that funding agencies are requesting a Data Management Plan (DMP) as an elementary part of the project proposal. The re-use of data implies yet more additional information on provenance, semantics and structure as the data is re-used outside of its original context. This has been approached through different sets of principles – e.g. the G8 Principles for an Open Data Infrastructure[10] and following G7 Science Minister's Meeting in 2015[11] and 2017[12].

Digital facilities provide their own users with data that have been already treated. The re-use of these data may require to be exhaustively informed about the preliminary treatments and, especially for analytical experiments, about the initial experimental conditions. Otherwise, to know more about the original data would require going back upstream into a complex process. The traceability of how the data has been produced and treated is therefore of crucial importance. Interoperability is not enough if it is not possible to know which context the data actually relates to. In addition, it may be of upmost importance to reconstitute the initial conditions of an experiment, in order to demonstrate the reliability of the results. To this purpose the facility must be able to keep information on these conditions, as well as on the post-experimental data treatments. More transparency in the data management and the provision of the above mentioned metadata is the only one condition for reinstalling a real "chain of fairness and confidence" in that sense.

10. G8 Open Data Charter and Technical Annex (2013)
https://www.gov.uk/government/publications/open-data-charter/g8-open-data-charter-and-technical-annex

11. G7 Science Ministers Statement Berlin DE, 8-9 October 2015
http://www.g8.utoronto.ca/science/G7_Science_2015-en.pdf

12. G7 Science Ministers Statement Turin IT, 27-28 September 2017
http://www.g7italy.it/sites/default/files/documents/G7%20Science%20Communiqué.pdf

4.3. Establishing new business relationships and policies on re-use of data

An open-innovation ecosystem should rely on a transparent open-science system. The economic crisis and the subsequent times of austerity made the national resources available for research scarce and put sometimes the RIs in difficult positions for justifying their costs. As a consequence, the strengthening of the socio-economic and societal impact of RIs became more and more a major concern for RI managers. Re-use of data – away from its initial purpose – demonstrates the innovative opportunities that access to, and curation of, data can achieve. Raising awareness of this opportunity with industry should be considered as a key focus that can reap rewards for all involved. In particular, RIs need therefore new types of experts capable to extract and valorise research data for industrial, economical and societal needs. This implies the development of new academic curricula and of specific training for data experts and practitioners.

In this context new business relationships are being developed between the socio-economical stakeholders such as industrial companies – and also policy decision-makers and public services – and the research labs – usual users of the RIs and of the research data the RIs produce – which are acting as (data) intermediaries between RIs and society. This "intermediary role" played by the researchers – users of RIs – is not always clearly defined nor the specific role of the RI itself as service provider. The latter is domain specific and should be explicitly acknowledged and transparently dealt with on a case by case basis in order to reinstall a real "chain of fairness and confidence" in these new and multilateral relationships.

An example on how e-RIs can integrate innovation activities is given in the **BOX 13** on **How Elixir integrates innovation in its activities.**

HOW ELIXIR INTEGRATES INNOVATION IN ITS ACTIVITIES

ELIXIR is a pan-European distributed infrastructure for life-science information. It connects national bioinformatics centres and EMBL-EBI into a single infrastructure for biological research data and underpins life science research across academia and industry.

Within ELIXIR, an Industry Advisory Committee (IAC) has been set up, composed of external experts from a range of commercial actors of different type and size. The IAC provides high level strategic advice to ELIXIR in order to improve added value to industrial users. Here, public bioinformatics resources already have a large user-base in industrial R&D. Challenges identified by the IAC are: the fragmentation of bioinformatics resources which is neither optimal nor sustainable; the need to ensure long term sustainability; and provision of training to industry.

The ELIXIR "quality stamp" (for reliable data) and ELIXIR Node network contacts throughout Europe (sustainable network) are deemed to be highly beneficial to industry. ELIXIR participates in joint research and development projects and in new forms of Public Private Partnerships with industrial partners. Industry is also an important supplier to the life science sector which is already a big consumer of ICT computing services and this will increase further. Public data infrastructure is obviously a foundation for innovation. The number of patents from public data archives is growing.

ELIXIR acts as a broker and awareness raiser for industry. It offers targeted support to Europe's SMEs that build services on top of the public bioinformatics resources. ELIXIR definitely helps them to save time (e.g. in data integration) and to better understand socio-economic impact. ELIXIR's Innovation and SME programme organises dedicated showcases and is tailored to reach the deep fabric of industry/SMEs clusters (in pharmaceutical, agro-food, biotech, marine informatics, rare diseases, etc.).

BOX 13. How ELIXIR integrates innovation in its activities

One should also stress that the value of the data generated by the RIs is often dual: a use value for science and society and an economic value for a competitive market. This involves decisions on pricing for commercial use of data, requiring the definition of a data policy for allowing commercial use and re-use of data. Promoting the free access of industry for commercial use of data is obviously a way to foster innovation. But other factors need to be taken into account in establishing the data policy: the long term sustainability of the RI through public funding; ethical and political issues – including in some cases the social responsibility and "impartiality" of the RI – and the implementation of a win-win approach to innovation between RIs and industry – co-sharing risks and benefits.

Moreover, industry – especially SMEs – is often interested in using raw data collected and disseminated by RIs – e.g. in the environmental sector, as pointed out by the EPOS Project Development Board in August 2015 – to generate value-added data products. In some cases, RIs and SMEs might be in competition for delivering data products (for example with remote sensing data). Examples have been given of SMEs developing products for industry by using scientific data accessible through data infrastructures without any proper citation or acknowledgement of data providers (scientists). So, the free access for commercial use of data does not only raise legal – e.g. the protection of IPRs –, governance and financial issues but also technical IT ones. Indeed, addressing and adopting effective IT solutions for data traceability and user accountability is mandatory in order to fully exploit open science and interact with private stakeholders. And here we are back once again to the "chain of fairness and confidence" that must be developed in a truly transparent approach.

The **BOX 14** provides a miscellanea of **ESFRI Landmarks' current practices in industry access to data** (information extracted from a survey made by the EC in 2015).

ESFRI LANDMARKS' CURRENT PRACTICES IN INDUSTRY ACCESS TO DATA

HEALTH

BBMRI: *Expert Centres (public-private partnerships)* will engage academia and industry in a collaborative pre-competitive research process with the aim to generate well-standardised primary omics data from quality-defined samples provided by BBMRI. These data can be used by industry for biomarker or drug development and will contribute to establishing a quality controlled common knowledge-base (e.g. plan for a BBMRI associated Expert Centre in the area of translational research to be developed with the European Federation of Pharmaceutical Industries and Associations, EFPIA).

EATRIS: national nodes follow all current national and European legislation on data handling, as well as strict adherence to institutional ethical principles. In all instances, institutions keep their right to publish.

ECRIN: the *Scientific Board eligibility* criteria include the commitment to publish trial results, and the commitment to provide access to patient-level data upon request. No commercial use will be made of the data.

ELIXIR: existing databases and analysis tools are used extensively by industry. These resources range from databases on human genomic data through to value added knowledge bases. The access policy is determined at the level of that resource as it often depends on the type of data and ethical issues around it; in cases of sensitive data, access is first vetted through a *Data Access Committee*.

INFRAFRONTIER: all mouse mutant resources are being distributed on a cost recovery basis to support basic and applied research. Access to data held in the EMMA repository database is free to all users. Access to phenotyping data generated in projects for industry partners is private and data access covered in specific collaboration agreements.

INSTRUCT: after initial priority access to the data for the scientist(s) carrying out the experiment (embargo period), the data is publicly accessible and reusable. Industrial users are referred to the INSTRUCT data management policies.

SOCIAL SCIENCES AND HUMANITIES

CLARIN: generally supports and actively promotes free and open access, but commercial use of data will have to be agreed or negotiated between user and owner.

ESS Social: data, documentation and tools are freely available for non-commercial use. The ERIC Statutes provide that commercial use of the ESS data will be handled on a case by case basis.

SHARE: commercial use of the data is not permitted in order to protect the personal data provided by the respondents.

PHYSICAL SCIENCES AND ENGINEERING, ENERGY, ICT

ESRF & ILL: data collected under paid for service agreements are owned by the client. Free access: after initial priority access to the data for the scientist(s) carrying out the experiment (embargo period), the data is publicly accessible and reusable.

JHR: the experimental data will be the property of the contract owner in case of proprietary programmes or will be shared by the group of partners in case of an international joint programme.

SPIRAL2: the access for the industry users is provided on purely commercial (individual contracts) basis.

PRACE: access is free of charge and proposals from industry must compete with proposals from academia using one single criterion: scientific excellence. PRACE users do own the data produced by their simulations. But they must publish results. PRACE decided to award access only for Open R&D to avoid any legal issues with industrial access.

ENVIRONMENT

EMSO: promotes free and open access to data to any person or organisation who requests them without having to state an interest according to Aarhus Convention on environmental data, the INSPIRE Directive and the Directive 2003/4/EC (on public access to environmental information). Requested data shall be made available in a timely manner, preferably online and free of charge. In accordance with the above mentioned directives, EMSO however may apply charges for cost intensive data provision services and will apply restrictions on access to a series of specific validated data.

EURO-ARGO: data policy guarantees a free access to data for all interested users. There is a complex added value chain going from raw observations up to ocean analysis and forecasting services. Industrial applications are not using raw data coming from the Argo network, but products provided by services like *Copernicus* that combine *in situ* and satellite observations into an oceanographic model.

IAGOS: airlines contributing to the operation of IAGOS are granted free access to the data base. The specific contract for data provision from IAGOS to the *Copernicus Atmosphere Monitoring Service* (CAMS) is under negotiation. ECMWF will contribute to the cost of data provision in near real time and real time as requested for operational services in the frame of CAMS. Commercial use of the data is not promoted so far.

LIFEWATCH: access is open to all users without discrimination.

BOX 14. ESFRI Landmarks' current practices in industry access to data (from the survey of ESFRI Landmarks, 2015)

Industry as a potential data supplier

Industry – and SMEs – can potentially be data supplier to RIs – e.g. in environmental sciences, as noted by the *EPOS Project Development Board*. Indeed, industry can be involved as "usual" supplier (see **Chapter 2**) in developing technology for building RI elements – sensors, experimental devices, digital acquisition systems, etc. and it can provide access to facilities hosted in private organisations. But industry can also generate data and data products that could be potentially accessible through the public RIs. However, the integration at pan-European level of public data collected by the national nodes of a distributed RI with data generated by industry is not always feasible or practical for different reasons among which the lack of shared open access policies – e.g. for most of the geophysical data collected by industry such as for geo-resources and anthropogenic hazards – and the potential conflict between the regional / national interests of industry and the pan-European dimension and perspective of the RI. Nevertheless, new industrial collaborations of this kind could occur.

4.4. The current research data landscape

The research data landscape, including data connected to RIs, is still fragmented. Some disciplines like climate research and astronomy have built well-established frameworks for global access data exchange within their communities. In other disciplines active work towards common standards and systems is on-going – e.g. **The Photon and Neutron data infrastructure initiative PANDATA** of major European analytical facilities (see the **BOX 15**) – but substantial challenges remain to be tackled. In many cases, the massive innovation potential inherent in the data connected to RIs remains to be explored, but the field is in rapid development and significant progress can be expected in the coming years. When it comes to cross-disciplinary activities, the notions of "building blocks" of common fundamental data infrastructures and building specific "data bridges" to facilitate cross-field access and use are becoming accepted metaphors for approaching the data complexity and to enable data sharing.

THE PHOTON AND NEUTRON DATA INFRASTRUCTURE INITIATIVE PANDATA

PANDATA brings together major world class European RIs (analytical facilities) to create a fully integrated, pan-European, information infrastructure supporting the scientific process. The PANDATA Europe strategic working group has developed a policy framework and laid the basic foundation for a sustainable data infrastructure. PANDATA Open Data Infrastructure, a FP7 supported project, took up these developments to create a federated open data infrastructure, seamlessly integrating the existing user and data management systems of the European photon and neutron facilities. The aims were to provide a rich eco-system of federated services useful for both the facilities as well as the scientific user communities. **PANDAAS**, Photon and Neutron Data as a Service, is a follow-up project funded under HORIZON 2020 whose objective is to include data analysis service into the facility provision. These efforts will undoubtedly significantly stimulate the innovation potential of the participating RIs and their collaboration with industry. The initiative is also trying to align its activities with the recommendations and developments of the Research Data Alliance. The RDA could provide a perfect platform to promote collaboration across the European landscape and therefore a Photon and Neutron Science Interest group (PaNSIG) was set up, recognized and endorsed by the RDA in 2014.

BOX 15. The Photon and Neutron data infrastructure initiative PANDATA

Sharing of best practice

Research communities are almost by default internationally organised, and they all rely on e-Infrastructures often provided by national organisations and ICT service providers. The European Commission has, in particular through FP7, invested significantly to organise the national research ICT service providers into common e-Infrastructures covering the European Union. These initiatives include the GÉANT, EGI, EUDAT, OpenAIRE, Zenodo, Helix-Nebula and PRACE, each focussing on different e-Infrastructure aspects ranging from wide-spread digital connectivity to data identification, to high performance computing using very powerful centralised computing resources. The e-IRG has presented recommendations aiming at building data bridges, including also other aspects of e-Infrastructure for enabling data communication and analysis, in the form of the e-Infrastructure Commons Initiative[13]. Many of the European e-Infrastructure projects and initiatives have also already taken significant steps towards providing common pan-European services for research communities in general, hereby implementing this Initiative. Also, a main focus of the e-Infrastructure programme within H2020 is on integration and the provisioning of a coherent catalogue of services for users. In this context, ESFRI plays an important role, enhanced by the mandate received from the European Competitiveness Council that – in the conclusions of the 29th May 2015 meeting – "*INVITES ESFRI to explore mechanisms for better coordination of Member States' investment strategies in e-Infrastructures, covering also HPC, distributed computing, scientific data and networks*"[14].

A well concerted effort involving national and Commission resources regarding all the building blocks of the e-Infrastructure – i.e. computing resources, data transmission resources, data storage resources, strategic software and training of data scientists and practitioners – is needed to shape an open science system that will broadly benefit science, society and economic activities. The European Commission has also recently launched the development of the European Open Science Cloud (EOSC)[15] which aims to create a trusted environment for hosting and processing research data to support EU science

13. e-Infrastructure Commons Initiative http://e-irg.eu/documents/10920/290578/e-Infrastructure+Commons+summary.pdf/
14. Conclusions of the Council of the European Union of 29 May 2015 on Open, data-intensive and networked research as a driver for faster and wider innovation. Doc. 9360/15 http://data.consilium.europa.eu/doc/document/ST-9360-2015- INIT/en/pdf
15. European Open Science Cloud (EOSC) https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud

in its global leading role, based on open access and FAIR data – findability, accessibility, interoperability and reusability – principles.

All these converging efforts and projects will definitely strengthen the innovation potential of the involved RIs and contribute to increase their attractiveness for industry.

4.5. Recommendations on data management

ESFRI and e-IRG have jointly presented in 2013 a comprehensive list of actions that should be taken to arrive at a situation where research and society can reap the full benefits of Research Infrastructure data, including aspects of innovation[16]. These recommendations are still valid but they should be put in perspective, in particular, with the development of the EOSC initiative and more recent e-IRG documents[17].

As a basis for RIs, sustainable e-Infrastructure services for enabling access to, storing, preserving and curating large amounts of data need to be in place.
To focus on strengthening and improving the relations between RIs and industry in addition to the promotion of the potential for innovation of RIs, any successful data policy should include a series of essential elements.

The roles and responsibilities of the different actors (including infrastructure and service providers, data owners, and academic and industrial RI users) need to be clearly identified and effective and cost-efficient solutions that fulfil the needs of the industrial users and data owners should be ensured (in cooperation). In particular, the costs for different services and procedures should be made transparent and different economic models for implementing them should be investigated (especially for the commercial re-use of data). The RIs should ensure research data availability across borders and disciplinary domains, the provision of metadata (enabling the traceability of how the data has been produced and treated), and data handling and portability of results (which is becoming more and more important in many industrial sectors and which needs to be considered in

16. Summary of Policy Recommendations Drawn from the e-IRG Blue Paper on Data Management http://e-irg.eu/documents/10920/238805/BP-summary-policy-130227.pdf

17. Guide to e-Infrastructure Requirements for European Research Infrastructures e-irg.eu/documents/10920/363494/2017-Supportdocument.pdf

cooperation). Specific training for data experts and practitioners and appropriate academic curricula should be widely developed.

Specific work packages on industrial cooperation and innovation should be included in the cluster projects supported by the EC and coordinate horizontal activities on this topic between the different thematic cluster projects. And finally, RIs should ensure that opportunities are in place to encourage the sharing of best management practice across e-Infrastructure and data management service providers, as a means to enable more effective and efficient operations.

5. A new innovation culture

5.1. Improving mutual knowledge and cooperation: the role of intermediaries

A change of culture is needed in both RIs and industry. All stakeholders should be better informed on, and more aware of, the existing potential for cooperation. Industry should become more RI oriented and RIs more business oriented. The right balance between business-oriented activity / service provision and scientific collaboration is difficult to determine, and depends on each specific case. It is not clear if a minimum for service provision – 10%, 15% or more of total revenues – should be fixed, it depends very much on the specificity of each RI.

Improving awareness is a key requirement. RIs should develop more systematically outreach activities and "industry days" with true business development managers able to help them to answer the question "How best to sell RIs?". The organisation of industrial exhibitions linked with major scientific conferences became common practice. Raising awareness on RI opportunities and their socio-economic impact is needed in all directions: towards RIs themselves, industry and a wider audience (including policy decision makers and the general public). Contacting former PhDs of the facility and maintaining their awareness for using the facility is important. There is indeed an obvious problem of fewer European PhDs with an industrial focus than e.g. in Asian countries and this reduces the absorption capacity of new scientific knowledge in European industry.

Within this context the full range of contributions of industry to RIs should be better highlighted: not only as a service provider during the construction phase and operation but also via the various access modes and the investment of industry in the neighbouring of RIs (stimulation of the creation of innovation ecosystems). Consequently, industry should be associated in the evaluation of RIs. Symmetrically, the evaluation of academic research teams who use the RIs should take into account their collaborations with industry, including the resulting socio-economic impact.

The role of professional intermediaries and of specifically dedicated cooperation mechanisms and tools is absolutely essential to strengthen the cooperation between RIs and industry, and between RIs themselves. "Intermediaries" are very diverse: industrial liaison officers, purchasing officers, knowledge and technology transfer offices, experts in industry advisory boards, etc. RTOs and academic institutions – research teams, university interfaces with industry –, in particular within projects jointly supported or driven by industry, are also essential actors. Private business boosters – business angels and venture capital – specialised in high-risk investments and the creation of high-tech companies are another category of actors to be considered. They can offer an alternative to the full-in-house business plans – from IP protection to spin-off creation. All of these steps require indeed adequate entrepreneurial skills and financial capacity as well as professional industrial vision and motivation.

The activities of all these intermediaries should be better known and promoted, and closely coordinated – e.g. with specific open-days dedicated to intermediaries. Due to the huge complexity of the innovation processes and diversity of RIs – including the specificities of distributed RIs and of the e-RIs – not one solution fits all: the wide diversity of intermediaries and schemes is justified.

5.2. Industrial Liaison Officers

The establishment of responsible and proactive relationships with industry through an industrial liaison office is a key requirement. The mission of the Industrial Liaison Officer should be strictly defined and her / his position within the facility be clearly specified. He / she should be in charge of:

- raising awareness, building relationships and prospecting new business opportunities with industry as a supplier or / and as a user;
- identifying intermediaries (RTOs, contractors, etc.) and informing them regularly;
- defining flexible business models adapted to users' needs;
- increasing market understanding and assessing competitiveness.

The installation of ILOs – and whereas appropriate of TTOs (see **Section 3.5**) – should be encouraged in all RIs – including in the central hubs of distributed RIs. This is current practice in the EIROforum member organizations and should become a common requirement for all ESFRI RIs too. These ILOs should closely cooperate at EU level. ILOs (and purchasing officers) are also appointed in national RI funding agencies. Their efficiency and effectiveness in improving industrial return to member countries of pan-European RIs – including the return to their commercial firms – is well proven. Networking of these national ILOs (around each facility and / or more broadly in thematic areas) is a good practice that should be extended. It is indeed important that ILOs from all countries work together to feedback to the facilities, for example to help them improve the procurement rules. More generally all networking activities between RIs should systematically put the issue of RI-Industry relations on their agendas. See the **BOX 16** on the **Role of ILOs at STFC on industrial return**.

ROLE OF ILOs AT STFC ON INDUSTRIAL RETURN

BARRIERS	ROLE OF ILOs
- A new market to many companies: they have not heard of RIs - Tenders are promoted only through the ILOs or the facility directly. Not open: can be hard to find	**Roising awareness and building relationships** *Aim*: To have a cohort of interested, relevant companies who are aware of the tender opportunities and engaged with the facilities
- International market: companies may feel they need to be familiar with the country - Language barrier - Unfamiliar procurement rules	**Increasing market understanding** *Aim*: Companies understand how to work with facilities and are winning contracts which allow them to gain confidance in the sector, strengthe their links and win future work
- Competing with companies across Europe	**Assessing competitiveness**

RAISING AWARENESS AND BUILDING RELATIONSHIPS

- Maintain and grow a database of companies working with or interested in working with RIs
- Conduct market analysis to identify suitable companies for tenders
- Identify new companies and build relationships by visiting industry (sector events, site visits)
- Send through relevant tenders and news
- Host events to raise awareness or to introduce companies to specific buyers and help to build that relationship
- It is important that companies develop a relationship with the key technical staff:
    - More likely to be put forward for tenders
    - Can access lower value tenders
    - Learn about projects in advance of the launch of the tender

INCREASING MARKET UNDERSTANDING

- Ensure that companies understand the procurement rules and know that they can come to ILO for support
- Link them with other sources of support to help them export: help them learn about the market: not all "high tech" requirements / many have English as an official working language / pricing is key

OTHER POINTS TO NOTE

- Some facilities can be quite different culturally; both to what companies are used to in their country and to each other. As well as helping companies enter the RI market, ILO also helps them move between RIs
- The ILOs from all countries work together to feedback to the facilities and help them improve the procurement rules

MAIN KEY MESSAGE

It is vital that companies have:

- Personal contacts
- Early engagement
- Full understanding of the requirements

ADVANTAGES TO SUPPLIERS

A review of CERN's suppliers found that companies:

- Developed new products
- Acquired new customers (other than CERN)
- Started new R&D teams as a direct outcome of the CERN project
- Opened a new market
- Increased their international exposure
- Indicated technological and market learning
- Had improved employment growth

BOX 16. Role of ILOs at STFC on industrial return

5.3. The example of the analytical facilities

The analytical facilities represent an underexploited pool for European industry. Both industrial suppliers and users, and the research facilities would benefit from standardised collaboration procedures. To enhance interactions with industry, the **EU-funded Integrated Activities CALIPSOplus (accelerator-based light sources) and NMI3 (neutron and muon sources)** have set up a pan-European Industrial Advisory Board in addition to organising joint networking activities with industries both as users and instrumentation suppliers (see the **BOX 17**). Another example showing how to make integrated access to nano-labs and LSFs user-friendly and attractive is provided by the **EU-funded Integrated Activities NFFA-Europe for nanoscience** (see the **BOX 18**).

This type of networks brings together on one side representatives of the RIs – industry liaison and purchasing officers, etc. – and on the other side (carefully selected) experienced representatives from industry.

EU-FUNDED INTEGRATED ACTIVITIES CALIPSOplus (ACCELERATOR-BASED LIGHT SOURCES) AND NMI3 (N- AND μ-SOURCES)

Major points raised by the Industrial Advisory Board and to be addressed by RIs to provide a high quality access, service and collaboration for and with industry

ACCESS TO RESEARCH INFRASTRUCTURES / LEGAL ISSUES

- Specific beamtime slots could be kept fixed for Industry. Such a system is already in operation in some facilities and some beamlines, but not in all. It would seem wise to share learning and experience to implement the system in those facilities willing to increase their industrial use.

COST/BENEFIT - COMMUNICATION OF TECHNIQUES

- The cost of beam time is often highlighted as a hurdle for industry, but what really matters is the cost-benefit ratio. Consequently, benefits need to be clearly communicated in a form that is appealing (and comprehensible) to industry.
- “Scientific translation” is a two-way process. It is necessary for scientific RI staff to successfully translate new scientific opportunities to a language that make the opportunities understandable and appeal to industry. However, it is also highly beneficial if industry demonstrates that many of its challenges contain a core of interesting and challenging science.

SERVICE / COLLABORATION / TRAINING OF INDUSTRY STAFF

- Whenever possible for practical reasons and necessary for scientific reasons, industry should have the option to purchase beam time along with a skilled beam line scientist.
- The increased industrial focus on precompetitive collaboration opens new possibilities to build industrial-academic consortia around scientific areas of interest to several partners. This distributes costs to address unfavourable cost-benefit ratios.
- Poor or non-existent harmonisation of software is a concern. Data processing software (in particular on-the-fly processing of raw data) should be user-friendly, standardised and transparent in order to benefit industrial use, whereas this aspect is far less critical for software used for further, more complex and specialised, data analysis.

ACCURATENESS AND TIMELINESS VS. PUBLISHABLE SCIENCE

- Validation of experimental methods and techniques is not always strictly necessary for industrial use. This is particularly true for methods designed to provide scientific understanding (rather than actual testing and analytical work). Increasing industrial focus on quality by design (rather than quality by inspection) increases interest of non-validated and more explorative methods.

INCENTIVE FOR INSTRUMENT SCIENTISTS / GROUP – MANAGEMENT ISSUES

- Part of the income from industrial projects should go back to the instrument or beamline for their scientific use, rather than all being put into a general overhead account. This would create additional incentives for the beamline team to spend time and effort on industrial projects.

BOX 17. EU-funded Integrated Activities CALIPSOplus (accelerator-based light sources) and NMI3 (N- and μ-sources)

EU-FUNDED INTEGRATED ACTIVITIES NFFA-EUROPE FOR NANOSCIENCE

NFFA-EUROPE makes integrated access to nano-labs and LSFs user-friendly and attractive to SME and Industry.

NFFA-EUROPE sets out a platform to carry out comprehensive projects for multidisciplinary research at the nanoscale extending from synthesis to nanocharacterization to theory and numerical simulation. Advanced infrastructures specialized on growth, nano-lithography, nano-characterization, theory and simulation and fine-analysis with Synchrotron, FEL and Neutron radiation sources are integrated in a multi-site combination.

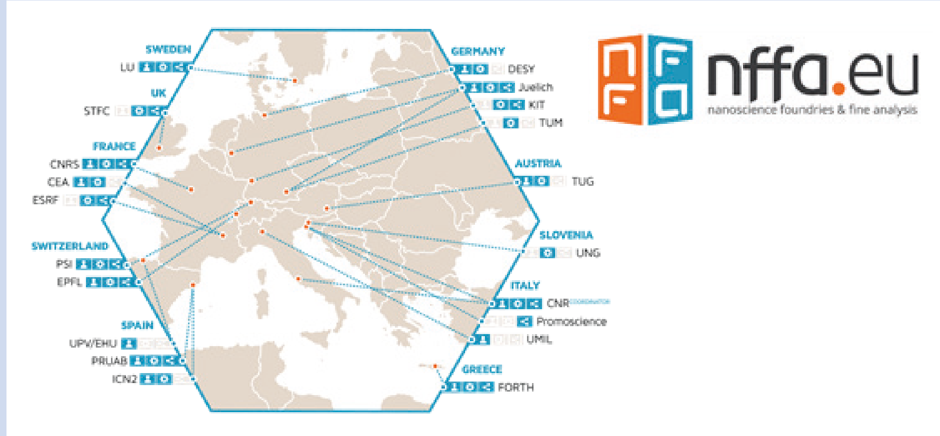
Users, by visiting a Single Entry Point, can easily navigate through an online Catalogue and select a "wish-list" (automatically generating the proposal draft) which is then processed by the Technical Liaison Network (TLNet): the backbone providing feedback to requests and questions and liaising with contact scientists and specific instruments. A mechanism similar to the peer-review system of an editorial board is used to promptly obtain technical responses from the NFFA installations, and the best "reviewed" solution for the user is setup, including assessment on the technical feasibility and the assignment to the best suited NFFA-Europe sites.

An ICT platform allows to get a full overview of all the proposals and requests, where technical comments and access status are updated and shared. A single communication channel between users and providers has been identified in a Forum, for debating work-plan and access scheduling. Such a wide technical participation drives a reciprocal technical awareness among the NFFA-EU sites, improving the technical capability as a whole team.

The TLNet and industry & business development staff of the NFFA-Europe nodes support efficient access for industry. The outreach to industry is performed both at consortium and at single node levels in the European and regional eco-systems. To help build the case with industry incentivized knowledge transfer allows industry experience to be built through feasibility and pilot studies on the NFFA-Europe facilities.

A specific one-stop-shop addressed to industries and in particular to SMEs, is accessible by "click" on the website. The full technical offer, but also the different access modes, from open access to proprietary research, passing through feasibility tests, and the related confidentiality issues, can be discussed and quickly translated in proposals submission or service contracts. An advanced Data Management Plan is developed that will be offered in the future also to industrial users and SMEs.

NFFA-Europe has an average 10% direct industrial access requests out of the total number of proposals.



BOX 18. EU-funded Integrated Activities NFFA-Europe for nanoscience (from www.NFFA.eu website)

Many factors impede industrial uses of analytical facilities. It is typically recognized that industry doesn't take full advantage of what can be done by RIs and that most of engineers and (potential) industry users don't have the skills and experience, and are often not familiar with the language and scientific terms used at RIs. In particular, industrial users have poor understanding of the beamtime allocation procedure. Key issues for characterization of materials are well identified: access schedule, non-disclosure agreements, costing, accuracy of measurements and accreditation of RIs. In order to cope with these generic difficulties, it would be necessary to develop and apply standards when industrial users conduct experiments in the facilities. The need of a unique portal with links to all analytical facilities is regularly emphasized as well as the potential of a full service, including the interpretation of data. This would imply additional internal resources which should be made available by the RIs.

Moreover, the academic and industrial communities have different and, sometimes, contrary needs. For instance, industry may require the analysis of a larger amount of samples and immediately exploitable results than the academic community does. One major issue identified is the different way in thinking of industry and facility research staff. Industry needs rapid access to beam time and efficient generation of scientific results, whereas facility staff tends to be motivated by scientific questions of a more academic, less time-bound nature. Facility staff therefore needs to be rewarded appropriately and motivated to respond to industry demands which, for example, may not lead to publications. Dedicated staff and an efficient user-interface – e.g. sample environment and software for instrument control and data treatment – are the basis for attracting commercial users.

New business models are emerging to address these barriers. One is the existence of facilitator companies that bridge the gap between large-scale research facilities and the commercial world, a new type of intermediaries or "brokers" which provide specialised expertise to industry. These small businesses know both aspects very well, as they work with industry and are familiar with facility-based experimental techniques. They provide the service needed by the commercial user and they offer the expertise of the research facility researcher. Despite the European scope of research facilities, fostered by European funded projects, these emerging companies illustrate the regional economic impact of large scale infrastructures, geographic proximity facilitating effective interaction with industry. Another model is the support to interactions between high-tech companies and analytical facilities given through publicly funded projects and specialised technology platforms, at local / regional level or at a broader EU scale.

In 2017 a League of European Accelerator-based Photon Sources (LEAPS) has been created, whose goals include to strengthen interactions with industry, to exploit more fully the potential of Synchrotron and FEL facilities for industrial research and to develop and exploit enabling technology.

5.4. New collaborative frameworks for co-innovation

As was already pointed out, improving the quality and efficiency of RI-Industry cooperation requires also the establishment of a better collaborative framework between RIs themselves and with industrial companies. New promising initiatives have been launched some of them requesting the support of EU FP. A nice example of an open and collaborative approach – "co-innovation" – is represented in the **BOX 19** on **ATTRACT R&D&I collaborative framework and programme around Detection and Imaging Technologies**, co-funded by the European Union under Horizon 2020 and administered by CERN in collaboration with ESO, ESRF, ILL, EMBL and XFEL, and industrial partners. This is a first response to the need for pre-integration platforms open to industry described in **Section 2.4**.

ATTRACT R&D&I COLLABORATIVE FRAMEWORK AND PROGRAMME AROUND DETECTION AND IMAGING TECHNOLOGIES

ATTRACT is a novel R&D&I collaborative framework and programme around Detection and Imaging Technologies. It engages both the research communities using European Research Infrastructures (ERIs) and Industry with special attention paid to the Small and Medium size Enterprises (SMEs). It seeks the benefit of these stakeholders and the European society at large.

ATTRACT focuses on Detection and Imaging Technologies because they are crucial enablers for industrial competitiveness. They are as well key for pushing the limits of scientific knowledge pursued by ERIs. They also constitute an essential element for future applications, products or businesses targeting upcoming Societal Challenges. In summary Detection and Imaging Technologies boost the mission of ERIs, empower industrial goals and create sustainable social wealth.

ATTRACT proposes the paradigm of co-innovation. Right from the start co-innovating partners identify common synergies and subsequently co-develop and co-implement projects leading to mutual benefit. Co-innovation steers individual goals by optimizing know-how and resources towards a win-win outcome. ATTRACT proposes co-innovation as the process capable of respecting the fundamental mission of ERIs and at the same time generate industrial and societal value. In other words it translates Open Science into Open innovation.

	MAIN BENEFITS
INDUSTRY	- Access to a unique network of know-how and talent existing in ERIs - Reduced costs and time to market for developing breakthroungh applications - Development of new applications for new markets
RESEARCH COMMUNITIES	- Access to industrial talent, know-how and industrial manyfacturing capability - Unique opportunity to further develop and speed-up technology upgrading programmes - Seed long term collaborative links with industry - Opportunity to offer the research community industrial and entrepreneur-ship training

ATTRACT is a programme enabling a value added chain starting at ERIs. The mission of ERIs entails the invention, development and testing of a special kind of technology called breakthrough. Breakthrough technology creates new bases of industrial performance, new competitors and new business models and markets. When it is commercialized, widely accessible and put to service it generates transformative changes anticipating future societal needs.

ATTRACT is proposed as a flexible programme that also provides active support for young researchers to benefit from industrial training within and R&D&I setting. ATTRACT's co-innovation paradigm creates the conditions for young researchers to profit from the "hands on" contact with industrial environments. It thus increases their opportunities in the job market. In parallel, industry benefits from young talent. Also, existing ATTRACT pilot experiences with Master level students (i.e. IdeaSquare at CERN) show how a programme like ATTRACT, when deployed at full scale serves to create a future entrepreneurship culture.

BOX 19. ATTRACT R&D&I collaborative framework and programme around Detection and Imaging Technologies (from the ATTRACT White Paper, January 2015)

Another example is provided in the **BOX 20** on **Accelerator and Magnet Infrastructure for Cooperation and Innovation, AMICI**.

ACCELERATOR AND MAGNET INFRASTRUCTURE FOR COOPERATION AND INNOVATION, AMICI

The AMICI H2020 project aims to foster innovation in the field of particle accelerators and superconducting magnets and to facilitate industrialization by creating an open and globally available Technology Infrastructure (TI) for European Industry to use. The infrastructure will integrate European technological facilities previously established to build some of the most advanced European scientific Research Infrastructures like LHC, EU-XFEL, ESS, ITER, etc.

The AMICI Innovation-related activities aim at transferring the knowledge and know-how of research laboratories to industry and creating new products and new applications of direct benefit to society. For that purpose, Industry would access a pool of technical platforms made available by European Research Institutes such as test beam facilities, cryogenics, magnet and RF facilities and test benches, laboratories for material analysis and vacuum technology, for chemistry and surface characterization, for beam electronics and instrumentation, clean rooms and assembly halls including the equipment and the associated human expertise.

The Industrialization-related activities aim at keeping European industry at the forefront of the international competition, in terms of technology, quality and costs, in view of the construction of future scientific research instruments, in Europe and elsewhere. This will be achieved by fostering collaboration initiatives and opportunities between Industry and the TI that include: research and development of key technology prototypes, test and verification of industrial products, professional training and apprenticeship, certification studies and training (e.g. vacuum, cleanliness, welding, etc.), harmonization and standardization studies (e.g. cryogenics, material, etc.).

The AMICI project will explore and assess all the means to ensure that European industry:

- will have a clear view of the strategic science and technology roadmaps for the future accelerator-based Research Infrastructures worldwide and therefore they will be in a strong position to compete in the global market,
- will have a simplified and supported access to the most adequate technical platforms thanks to the stronger and optimized integration model established among the large existing technological facilities,
- will benefit from the integrated ecosystem that will foster innovation based on cutting-edge tools and developments and will enhance their visibility and competitiveness in new markets,
- will overcome their technology development barriers and further develop commercial opportunities within the Research Infrastructures and wider societal markets,
- will profit from the information exchange, definition of harmonized and standardized procedures and access to databases, which should allow cost reduction in the long term.

BOX 20. Accelerator and Magnet Infrastructure for Cooperation and Innovation, AMICI (from the AMICI Partner and Industry Days for Scientific Technology Infrastructure, April 2017)

5.5. Could the ERIC framework be a barrier to RI-Industry cooperation?

The question of whether the ERIC legal framework could be a barrier to collaboration with industry was raised. An ERIC is a public-public partnership for (mainly) non-economic activity – i.e. a public scientific mission). This doesn't hinder the activity of the industry as supplier of equipment and services. Moreover, an ERIC consortium is entitled to establish its own procurement rules and this flexibility is a real advantage. Industry as a user can be treated as any other user; IPRs and user fees can be managed according to the specificities / needs of every user or use. Moreover, an ERIC may also carry out limited economic activities closely related to its main task. The limit is not otherwise precisely defined in the regulation – or in the specific statutes of the ERICs – but it is usually estimated at 10%. This limit is not reached in the reality so far by any ERIC – e.g. proprietary research at analytical facilities amount to maximum 5%. Now if an economic activity is successful enough to be no longer considered to be secondary, the ERIC may consider creating a spin-off company for example. The benefits coming from the spin-off company can be used by the ERIC for its R&D and its development. This should be considered as the main instrument for developing more "industry-linked" commercial activities and to increase its socio-economic impact. Industry as a partner is another subject. Industry cannot become a member but well an associate or a contractor – e.g. industry could be a partner within collaborative programmes. One can conclude that the legal requirements of the ERIC regulation are not an obstacle – under current conditions – to the wish for increased industrial involvement in RIs (see Art. 3 of the ERIC Practical Guideline[18]).

18. ERIC Prctical Guidelines https://publications.europa.eu/en/publication-detail/-/publication/c6647f05-874e-4cdd-af70-22ade4759930/language-en

Nevertheless, some questions remain on the actual content of the concept of “economic activities” such as additional resources coming from the sale of services and other activities that are not tax (VAT)-exempted.

6. Socio-economic impact of Research Infrastructures

6.1. The wide range of impacts

As far as socio-economic impacts are concerned, relevant criteria for a typology of RIs are:

- scientific discipline: basic vs. applied, specialized vs. multidisciplinary;
- geographical distribution: single sited vs. distributed (local impact vs. national / European / worldwide impact - implications for funding);
- access mode: on site vs. remote / virtual (=> competitive vs. non-competitive);
- economic rationale: cost sharing among members vs. complementarity / diversity of resources;
- age and dynamics of evolution: new RI vs. upgrade / recovery of pre-existing resources.

The social and societal impact of RIs can be measured in several concentric circles:

(i) around the RI's immediate environment: including the residence area of the staff or the site of a partner-university providing the RI with well-trained PhD students;

(ii) at regional level: including R&D partner sites and industrial suppliers of midrange components or services;

(iii) at national or European / international level: including similar "competing" facilities and sites where internationally known companies provide unique high-level components all over the world;

(iv) in the whole European society whose quality of life benefits from the technological and scientific feats of the facility.

Moreover, it is impossible to design a unique ideal environment – and its structure, legal or not – for innovation. Free access labs, shared platforms, living labs, projects' hotels, spin-off centres, science parks, etc., all these kinds of structures now populate the campuses where RIs are installed. A key-point is the technical capabilities present in the surrounding area which consist of state of the art enabling technologies and support services. The very composition of this ecosystem is frequently in concordance with the main business activities of the facility. For this reason, it would be unrealistic to evaluate in an isolated manner the economic impact of a facility which is embedded in its own local or regional ecosystem of innovation.

The return on investment is generated primarily through knowledge production and transfer: advances in scientific knowledge and training of highly skilled people, use of the RIs as both a platform for scientific and technological collaboration, and as a service provider to industry. Measuring the effect of using a RI – "downstream innovation" – on the dissemination of new technology in the mass market model is difficult. The FP7 EVARIO study showed that the degree of involvement of the RI and the nature of stakeholders deeply determine the impact of innovation achieved in RIs on the overall return into economy.

That being said, industry is in principle willing to pay full access cost for relevant industrial use – "proprietary research" – but not for joint public-private investments in RIs. Mainly big companies which are typically able to conduct their own research programmes would be concerned. And in the operation of RIs, industrial participation should anyway be limited (see above) for various scientific, managerial and even legal reasons. Nevertheless, it is difficult to imagine a permanent scientific interest in a particular RI for basic research that could justify an industrial contribution to its creation or operation. Moreover, industry is not able to anticipate all potential benefits of RIs beyond its specific R&D needs.

Socio-economic impact is also achieved through technology acquisition and transfer: the construction and operation of the RIs, boosted by the leverage effect of the public purchase stimulating innovation of RI components, at the limit of the current technological possibilities. These components may benefit from the development made by the selling company and open the way to further development. Such developments may also be the source of strong public-private partnership. Thus the very ambition of a basic research project involving the construction of a RI will stimulate technological innovation by companies, including high-tech SMEs, and this in a very short period of time. In this sense, researchers, helped by SMEs, have minimized the "time to market" of what may later become an innovation worthy of greater public markets. A similar mechanism happens for e-RIs where the experimental instruments and equipment are replaced by ICT hardware and software.

Except the difficulty of measuring the economic impact of the innovation contained in this component through its indirect "snowball effect" in the other side-markets of the manufacturer e.g. security, health, transport or energy, it seems feasible to trace the economic impact of a RI-originated innovation in the mass markets, at least for "upstream innovation".

6.2. A broader view on impact and benefits of innovation and ways to measure them

Being innovative is not necessarily inventing; innovation refers to renewing, changing or creating more effective processes, products or ways of doing things. It does not only refer to partnering with industry or providing industry with a service but rather providing the opportunity to change a business model and adapt to changes in the environment to deliver better products or services. Innovation is the key to competitive advantage for any business. For RIs of pan-European or global benefit, this premise could mean implementing new ideas, creating dynamic products or improving existing services. Innovation can be a catalyst for growth and sustainability in an ever-changing scientific and technological global environment and so play a key role in ensuring the long-term value of research facilities to the European academic and industrial research communities.

Collaborating in an innovative environment can instil a similar sense of creativity to all partners. A currently ailing European manufacturing sector could benefit significantly through collaboration with RIs in investigating and enabling more efficient and effective production processes and best business practices resulting in the creation of more jobs. Finding innovative ways of raising awareness of the existence of RIs and how they can help industry is crucial in developing an open creative environment to conduct R&D having societal and economic impact. Hosting an industry-focused workshop with stakeholders from industry, academia and funding bodies, for example, will generate ideas for improving processes, products and services. The purpose of such an event could be to utilise available resources, including business advisors, from the science and engineering communities to help drive innovation. This may include seeking ways to protect intellectual property for commercialisation of ideas.

Successful innovation should be an in-built part of an organisation's business strategy and strategic vision, where an environment is created to facilitate innovative thinking and creative problem solving. As such, facilities – whether distributed or single-sited – should consider adopting a programme of self-assessment with "evolving through innovation" being the principal motive in carrying out such a process. Programmes of self-assessment by RIs, focused on innovation and innovativeness should be developed, and based on a limited number of sufficiently ambitious Key Performance Indicators (<10). Qualitative KPIs – generic, long-term – and quantitative ones – specific to the domain, short-term – interrelated with ambitious but realistic targets that should be achieved within a certain timeframe should be negotiated between the funders and the RI. It should also be recalled here that the major added value of TT / KT and innovation efforts are their broad impact (before money) and the creation of a new culture. RTOs have already defined KPIs, some of which could perhaps be used. See the **BOX 21** on **EARTO: Impact delivered and RTOs' three-stage innovation dynamic and funding model.**

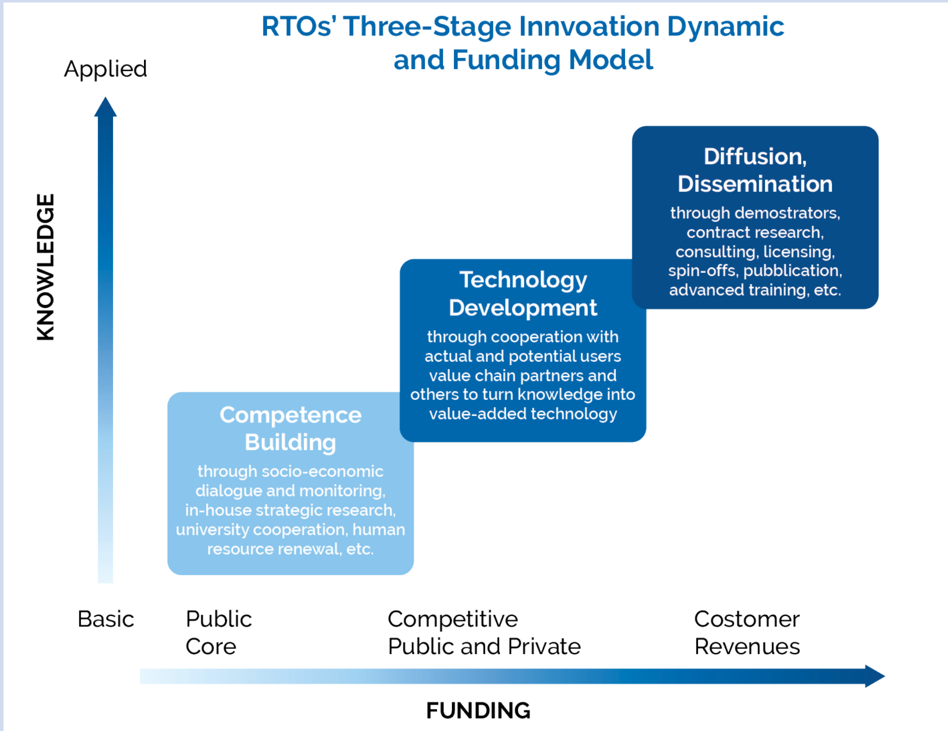
EARTO: IMPACT DELIVERED AND RTOS' THREE-STAGE INNOVATION DYNAMIC AND FUNDING MODEL

EARTO, the European Association of Research and Technology Organisations, has a vision to help create a European research and innovation system in which Research and Technology Organisations (RTOs) occupy nodal positions and possess the necessary resources and independence to make a major contribution to a competitive European economy and high quality of life through beneficial cooperation with all stakeholders. This vision is perhaps best represented through the Organisation's motto of Impact Delivered.

By way of supporting the network of RTOs and helping create a more innovative environment, EARTO has established a number of working groups (but not for RIs):

- Working with SMEs. Looking at H2020 funding instruments for potential opportunities for RTO-SME cooperation in addition to helping exchange best practices on national programmes of technology transfer between RTOs and SMEs.
- Quality Management & Excellence. Assisting Quality Managers across member organisations to exchange best practices.
- Communication. Finding ways on how to help members' communicate on the main ERA issues.
- Legal Experts. Developing an EARTO position on the revision of the state aid rules (GBER).
- Financial Experts. Exchanging best practices on financial and accounting issues related to H2020.
- Human Resources. Exchanging of best practices across member organisations.

In relation to identifying various sources of funding, the RTOs generally operate according to a three-stage "innovation dynamic", which transcends from basic through to applied research. This in turn informs a model for funding:



Synergies with RIs - RTOs as users and suppliers - could be strengthened in stages 1 and 2.

BOX 21. EARTO: Impact delivered and RTOs' three-stage innovation dynamic and funding model

Conclusions and recommendations

The recommendations made by the ESFRI Working Group on Innovation are drawn to the attention, beyond ESFRI, of a broad range of stakeholders who all have an interest in strengthening relations between RIs and industry:

- the RIs themselves, paying attention to the operational performance, the scientific excellence and the quality of the services delivered as a prerequisite for attracting users, and ultimately insuring the structural and legal sustainability of the facilities;
- the regional and national public funders, concerned by the attractiveness of their region or country;
- the European Commission and national funding agencies focused on the Grand Challenges, 2020 Horizon, the European Research Area;
- the academic users who are mainly concerned by doing the best research (in an open science spirit) and are also engaged in collaborative projects with industry;
- the business firms (SMEs, large companies, multinationals) which can be RI users or suppliers with specific R&D, innovation and / or sales objectives;
- private funders such as Charities or Foundations, whose objectives are more of a societal nature than of a strictly business one in terms of "return on investment".

Over the last years a series of recommendations regarding the RI-Industry relations and the identification of the potential for innovation in RIs have been made by the EU-funded projects ERID Watch[19] and EIRIISS[20] and by the Horizon 2020 Advisory Group on European RIs including e-Infrastructures[21]. INNO WG has indeed taken these references into consideration in its work.

INNO WG has agreed on the following conclusions and recommendations **for stimulating the various facets of innovation and industrial cooperation in RIs**.

19. ERID WATCH Report Summary (2011) http://cordis.europa.eu/result/rcn/48754_en.html

20. EIRIISS Report Summary (2012) http://cordis.europa.eu/result/rcn/55898_en.html

21. Horizon 2020 Expert Advisory Group on European Research Infrastructures Including e-Infrastructures http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=22494&no=1

Conclusions

1. A change of culture is needed in both RIs and industry. Industry should become more RI oriented and RIs more business oriented. All stakeholders should be better informed on, and more aware of, the existing potential for cooperation and of its huge socio-economic impact. Moreover, as shown in the report, innovation and industrial cooperation are obviously important factors that strengthen the RI long-term sustainability and contribute to the broadening and diversification of international cooperation links.

2. Raising awareness on RI opportunities and services and on RIs' socio-economic impact is needed in all directions: towards RIs themselves, industry and a wider audience (including policy decision makers and the general public). The role of professional intermediaries (e.g. Industry Liaison Office(r)s), of independent Industry Advisory Boards and of specifically dedicated cooperation mechanisms and tools is absolutely essential to strengthen and improve the cooperation between RIs and industry, and between RIs themselves. New initiatives should be taken to increase the attractiveness of RIs for industry.

   Dissemination and stimulation actions should be carried out in close connection with sectorial industrial organisations and RTOs, with the support of the EU. In order to move from the paradigm of technology transfer (TT) to the paradigm of knowledge transfer (KT), training of a new generation of engineers in industry more aware of science and RIs, as well as training of a new generation of researchers, more receptive to IPR issues and of industry needs, including mobility from academia to industry, are two essential blocks.

3. The concept of "industry as a full partner" (both as a supplier and as a user) should be proactively put in practice; this implies to

   promote more extensive partnerships on joint R&D projects and cooperative programmes, including the development of advanced technologies and innovation, training and exchange programmes, etc.

   RIs can offer industrial companies to be immersed in active ecosystems of innovation based on their complementary broad range of competences and skills. They are indeed most often located in S&T areas that include state of the art enabling technologies and support services. Such an environment makes more likely to grow a unique ecosystem around RIs well suited for innovation where research teams, small high-tech enterprises, spin-off and start-up companies, detached labs of big companies, TTOs and ILOs staffs all together exploit the "business at walking distance" advantage in working together on common issues in the same place.

4. A favourable political, regulatory, legal and financial environment is another condition for the successful implementation of a strategy aimed to strengthen and improve the relations between RIs and industry and to promote the potential for innovation of RIs in all its aspects. A series of needs expressed by industry and the RIs should be met and this calls for action by the funding agencies and political authorities e.g. on public procurement policies, IPRs, the knowledge of RI markets, the rules regulating State aids, dedicated funding mechanisms, etc.

5. Innovation should be considered in all its aspects. Indeed, RIs serve science and technology but also policy-making and society. The social, societal, ecological and public sector dimensions of innovation are particularly important for the ESFRI RIs in the Environmental, Health and Food and Social Sciences and Humanities sectors (and also for Analytical facilities). Most of them were built for their mixed scientific and societal impact, providing new knowledge, data and services to increase the

security, well-being and prosperity of a society faced with a series of Grand Challenges. Increasing the RI industrial cooperation is also important in this context, for both society and the economy.

6. Research data represents significant financial assets and business opportunities. It is also obvious that it is often still unclear how and on what conditions actors outside academia, especially commercial actors, can use such data due to IP and privacy issues. Re-use of data, away from its initial purpose, demonstrates the innovative opportunities that access to, and curation of data can achieve. Raising awareness of this opportunity with industry and developing transparent data management policies, including pricing policies if appropriate, should be considered as a key focus that can reap rewards for all involved, in a win-win approach to innovation between RIs and industry (co-sharing risks and benefits).

7. Finally, successful innovation should be an in-built part of an organisation's business strategy and strategic vision, where conditions are created to facilitate innovative thinking and creative problem solving. As such, RIs (whether distributed or single-sited) should consider adopting a programme of self-assessment with "evolving through innovation" being the principal motive in carrying out such a process.

Recommendations

1. RIs and Funding Agencies – including the EU – to raise awareness and improve information dissemination and mutual understanding

- Support the installation of Industrial Liaison Officers in RIs and RI funding agencies and promote their cooperation at European level; their tasks and position in the RIs should be clearly specified.
- Promote the creation of Industry Advisory Boards (as independent bodies or linked to the science advisory bodies whenever appropriate); composed of external experts from the various relevant industry and commercial sectors they should provide high level strategic advice in order to improve added value to industrial users-suppliers-partners.
- Raise awareness on RI access and services for industry with a European portal where the full range of access modes and collaborative regimes for industry would be highlighted, including information on prices and IPR conditions.
- Publish advanced and harmonized information on (future) Calls for Tenders, RI needs and TT opportunities, and upcoming procurements on a central European portal.

2. Improving industrial access

- RIs to establish a Quality Chart on access which would ensure a standard of quality and meet the expectations of the users.
- RIs to develop remote control access and virtual use of the facilities.
- Promote programme-based access open to long-term projects funded by research agencies, regional competitiveness clusters and

/ or private companies as an intermediate access mode between the strict scientific merit-based access and proprietary access.

3. RIs to develop business-oriented activities and services

- Develop more business-oriented activities, including specific support and services dedicated to industry, promote the skills of assessing, protecting and commercialization of inventions, and, where appropriate, the installation of a TTO.

- Provide companies – including SMEs – with new or more extended room near RIs dedicated to pre-competitive research programmes, where the possibility to exploit the RIs technological resources is more effective and where scientists and engineers work together in the same place on common objectives (open innovation and co-creation).

4. RIs to implement industry- and innovation-friendly data policies

- In order to fully exploit open science and to optimise interaction with private stakeholders, develop a transparent data management policy including effective solutions for data traceability, user accountability, provision of metadata, curation, long-term preservation and, if appropriate, pricing for different services and (commercial) re-use of data.

- Develop efforts to ensure research data availability across borders and disciplinary domains, and data handling and portability of results – which is becoming more and more important in many industrial sectors and needs to be considered in cooperation.

5. Increasing technological cooperation with industry – especially during construction / upgrade phases

- European RIs to anticipate the foresight of purchase of large equipment in European RIs. Involve industry as early as possible in large construction / upgrade projects with RIs – “industry as a partner”.

- RIs and the relevant Authorities to support the pre-development of highly innovative components supposed to be purchased by a large number of facilities (worldwide) and facilitate the common agreement for innovative purchase. Specific RI-Industry funding stream are needed – prototype development; “from lab to production line”.

- RIs and Funding Authorities to define Roadmaps and strategic agendas for key technologies for the R&D and construction of future (global) RIs based on platforms of significant size (T-Infrastructures). A supporting infrastructure for generic assembly, integration and test facilities should be developed at European level in association with industry – public-private partnership.

- More generally, develop new collaborative frameworks for co-innovation between RIs and with industrial companies.

6. RIs to improve their managerial tools with the support of the relevant Authorities

- Encourage the adoption of analytical accountability practices for the facility management in order to clarify and facilitate the elaboration of realistic and reliable operation costs. Moreover, this would also participate to the identification of hidden costs supported by the researchers' hosting institutes.

- RIs to consider adopting a programme of self-assessment based around innovation and ways of being innovative based on a limited number of sufficiently ambitious Key Performance

Indicators, including the potential of creating a new innovation culture beyond pure technology and knowledge transfers.

- RIs and the Funding Agencies to develop skills in support to the value analysis specialized in RIs – fast market studies, research of potential companies for taking over additional developments. Specialized market studies devoted to innovative components and RIs' calls for tenders should be systematically carried out in consultation between all the potentially concerned RIs.

7. RIs and the relevant Authorities to develop industry and innovation oriented funding streams, programmes and structures

- Develop dedicated funding stream for KT and TT at the most appropriate level – regional, national or even European.
- Develop more specifically addressed training and mobility policies and schemes.
- Promote the development of local or regional ecosystems integrating RIs, T-Infrastructures, Technology and Service Providers, Incubation Facilities and Industrial Users, namely an environment opening new opportunities for hosting projects with industry and where the added value offered by RIs and their complementarity with industry can be optimized – in scientific campuses, technology parks, etc. Extend the perimeter of the innovation ecosystems to new industrial partnerships, other than spin-offs and start-ups.

8. The relevant Authorities – at the appropriate regional, national and European level – to enhance the regulatory environment

- Encourage public procurement leverage effect (long-term markets). Possible improvements to the schemes (PCP and PPI) aimed to better involve industry in pre-commercial research and prototype development could be thought. The procurement procedures and rules need to be simplified and their transposition should be better harmonized in all EU Members States; specific national guidance tools and training sessions should be developed.
- Improve the efficiency of IPR policies (develop methodologies rather than models). For example, making use on a case by case basis of confidentiality-driven tools such as Non-Disclosure Agreements (NDAs) would definitely improve the efficiency of the RI-Industry collaborations.

9. Specific recommendation to ESFRI

- Continue to view systematically socio-economic impact as an integral component of all the ESFRI Roadmap assessment procedures and of the agendas of the networking activities of the ESFRI RIs. Develop the assessment methodology.

Appendices

Terms of Reference

1. Preamble

The role of the European Strategy Forum on Research Infrastructures is:

- *To support a coherent and strategy-led approach to policy making on Research Infrastructures in Europe and*
- *To facilitate multilateral initiatives leading to a better use and development of Research Infrastructures.*

To perform its tasks, the Forum may decide to set up Working Groups for assistance in specific topics which should report to the Forum. Every Working Group (WG) created by the Forum shall adhere to ESFRI's procedural guidelines and shall reflect the general ethos of the Forum aiming at the fuller development of the ESFRI action.

The Forum decides on the mandate of the WGs, including their duration and composition, their field of activity and specific terms of reference[22].

2. Rationale, general objectives and duration

Research Infrastructures (RIs) are a key instrument in bringing together researchers, funding agencies, policy makers and industry to act together. ESFRI has devoted considerable efforts in recent years to the identification of new or upgraded pan-European RIs for the benefit of European research and innovation. In addition, ESFRI played a highly stimulating and strategic role for the different national prioritisation processes and has given assistance to the Preparatory Phase of several projects.

22. These ToRs were ratified at the 41st ESFRI meeting

The ESFRI Roadmap for Research Infrastructures, published in 2006 and updated in 2008 and 2010, is a vital policy document and paves the way for the planning, implementation and upgrading of RIs for the coming decades. RIs contribute to making Europe 2020 Strategy and its Innovation Union Flagship Initiative[23] a reality. Moreover, RIs should help to realize the potential of the regions, to increase international cooperation and continue their opening to, and partnership with, industrial researchers and industry / services to help to address societal challenges and to support EU competitiveness.

ESFRI, at this time, has decided to concentrate on the implementation of the different ESFRI projects in order to fulfil the commitment of the Innovation Union Flagship Initiative that: "*By 2015, Member States together with the Commission should have completed or launched the construction of 60 % of the priority European Research Infrastructures currently identified by the European Strategy Forum for Research Infrastructures. The potential for innovation of these (and ICT and other) infrastructures should be increased*".

In May 2011 the Council of the EU invited ESFRI to "*contribute towards supporting the implementation and monitoring of progress of the Innovation Union initiative, and provide input, as appropriate, to the development of a proposal on the ERA Framework*"[24].

In this context a Working Group on Innovation (WG INNO), is set-up by ESFRI with the aim:

- To identify and promote the innovation and industrial capabilities of the RIs on the ESFRI roadmap;
- To strengthen the cooperation of pan-European RIs with industry;

23. Europe 2020 Flagship Initiative Innovation Union, COM (2010) 546 https://ec.europa.eu/research/innovation-union/pdf/innovation-union-communication_en.pdf

24. Conclusions of the Council of the European Union of 31 May 2011 on Development of the European Research Area (ERA) through ERA related groups. Doc. 11032/11 http://register.consilium.europa.eu/doc/srv?l=EN&f=ST 11032 2011 INIT

- To stimulate, where appropriate, the industrial involvement in the conceptual design phase of RIs;
- To promote the access of industrial users to the RIs.

The WG INNO will contribute to the implementation of the ESFRI Strategy Report. As a result the Group will propose to the Forum the broad lines of a strategic plan for an industry- oriented cooperation.

The duration of the mandate of WG INNO is two years. Its work, rationale and composition will be subject to review by ESFRI on a regular basis.

3. Topics and tasks

The tasks of the new WG INNO, under ESFRI's coordination and supervision, are focused on the following topics:

- Identify the role of RIs in the innovation process and monitor the related scientific developments in the different research domains.
- Identify emerging research challenges and technologies and the possible role of RIs as service provider (services which are distinct from those of test facilities or demonstrators).
- Develop contacts and links with the relevant European Industrial Organisations, Joint Technology Initiatives, SET-Plan, European Technology Platforms and EIT (European Institute for Innovation and Technology).

The main tasks that shall be undertaken by the WG INNO are therefore the following:

- Explore the major obstacles for enterprises to use publicly owned RIs, and identify the specific requirements for hosting industry users.

- Report to ESFRI on potential improvements in the pan-European accessibility and management of existing RIs and give appropriate expert feedback on the innovation and industrial aspects.
- Propose solutions to the problems of dissatisfying RI-Industry interactions.
- Propose a pragmatic approach to handle IPR issues and publication policies for the whole chain from pre-competitive research to industrial exploitation.
- Propose training schemes for young scientists to better cope with the industrial research requirements and for industrial staff to become acquainted with the innovation potential of the use of RIs.
- Analyse possible ways of an appropriate and effective cooperation with Joint Technology Initiatives, European Technology Platforms and Joint Programming Initiatives (related to industrial applications) to be further elaborated by the Forum.
- Analyse weaknesses of the ERIC regulation with respect to industrial use and consider innovation and technology transfer aspects during the setting up of ESFRI RIs.
- Explore possible links with SMEs.

As a result, the findings and recommendations will be summed up in a final report and contribute to the definition of the broad lines of a strategic plan for an industry and innovation oriented cooperation of the RI's.

4. Composition and method of work of the WG INNO

4.1. WG INNO Chair

In accordance with ESFRI's procedural guidelines, the WG INNO shall be chaired by an ESFRI member.

The duration of the mandate of a WG Chair is normally two years and should be adjusted to the mandate of the WG. The chairmanship may be extended for a further period (not exceeding two years) after agreement by the Forum.

The WG Chair is responsible for the timely and good organisation of WG meetings (including meeting agendas, drafting of minutes and related emails to the WG members).

4.2. WG INNO Membership

Nominations of potential candidates to the WG INNO shall come via the ESFRI delegations to the WG Chair who shall ensure that the composition of the group is sufficiently broad to cover the topics to be discussed, and shall also ensure that a good country balance is maintained[25].

WG INNO Members shall have high scientific, innovation, managerial and industry-related experience and be capable of contributing strategic and independent science and innovation-policy advice in all areas of S&T. They do not need to be members of ESFRI, but at least two ESFRI members (the Chair and in addition at least one further Forum delegate) should be part of the WG.

WG INNO should include a sufficient number of representatives from funding and innovation related organizations / institutions to ensure that the strategic and innovation perspective on the implementation of RIs is properly discussed.

If the balance of the nominations is not appropriate the WG Chair should alert the ESFRI Chair, who in turn will alert the ESFRI delegations.

The Chair may invite members of other WGs to participate as observers where matters of mutual interest are being discussed, in order to ensure coordination and awareness.

All WG members shall provide a fair and impartial contribution to the group and shall sign a statement declaring "no conflict of interest" to this effect.

4.3. Method of Work

The method of work includes:

- Regular meetings (normally up to 4 per year).
- Organisation of workshops if appropriate.
- Close cooperation with the Implementation Working Group (IWG), as well as the Preparatory Phase coordinators / Facility directors.

WG INNO may seek independent scientific, innovation, industry-related, technical or socio-economic advice making use, as necessary, of existing bodies and / or specific experts. When appropriate the WG shall propose to ESFRI the organization of specific workshops, to deepen the discussion in specific fields.

The WG shall not become the expression of any specific lobby-group supporting or opposing a specific proposal.

The WG shall report regularly to ESFRI via the WG Chair.

25. ESFRI Delegates may decide if they wish to be represented in any (or all) SWGs. There shall be no more than one member per country in each WG (excluding the Chair).

Potential recommendations to the Forum should be discussed beforehand with the Executive Board.

Members shall respect the confidentiality of discussions to facilitate and nurture open discussions and the outcome of meetings should be treated in a confidential manner, unless specifically stated.

5. Specific deliverables

The WG shall deliver in regular interval a report about its activities. General information on WG activities and WG reports shall be circulated via the ESFRI Secretariat. Only ESFRI is responsible for the final acceptance of the WG report which will be published on the ESFRI web site.

In particular, the WG INNO will:

- propose solutions to the limited interactions between RI and industry;
- make proposals to ESFRI for strengthening the cooperation of pan-European RIs with industry or relevant European Industrial Organisations to identify common goals.

The WG shall pay particular attention to the definition of Research activities as distinct from Development activities, and assess RIs as distinct from demonstration facilities or pilot plants and research programs / projects.

6. Resources and time scale

The WGs do not have any budget: participation of experts (travel & subsistence) must be borne by the members or their Ministry / host organization / institution. In case of meetings taking place in Brussels, the EC may offer logistic support (e.g. meeting room, sandwiches and refreshments) subject to availability and advance notice.

WG Chairs must provide their own secretarial support. They may be assisted by an EC official assigned to this WG.

The ESFRI Secretariat (with the support of the above-mentioned EC official) will provide access to a web-based facility reserved to the WG members, who can use it to share documents and information in a confidential way.

Membership

Members

Name	Affiliation	Country
MOULIN Jean **Chair**	Belgian Federal Science Policy Office, BELSPO	BE
CAMINADE Jean-Pierre	Ministère de l'Education nationale, de l'Enseignement supérieur et de la Recherche	FR
DOUGAN Claire **since 2015**	STFC	UK
ENACHESCU Marius	University Politehnica of Bucharest	RO
GOTTER Roberto	Consiglio Nazionale delle Ricerche	IT
LAAKSONEN Leif **since 2014**	e-IRG / CSC	FI
PAKKANEN Raimo	TEKES	FI
ROBIN Agnès	DG Research & Innovation	EC
RYAN Michael	SFI	IE
UHLÍŘ David	South Moravian Innovation Center	CZ
WEGENER Henrik	DTU	DK

Former members

Name	Affiliation	Country
FABIANEK Bernhardt **2013**	DG Research & Innovation	EC
LINN Alexander **2013** replaced by Hendrik Volrath, 2014	Forschungszentrum Jülich GmbH	DE
LOSKILL Renate **2013** replaced by Jutta Illichmann, 2014	BMBF	DE
MAMIMAARAN Sivasegaram **2013** replaced by Ione Isasa, 2014	DG Research & Innovation	EC
MIGUEIS Ricardo **2013**	Portuguese Foundation for Science and Technology	PT
VAN HELLEPUTTE Johan **2013 - 2014**	IMEC	BE
WOODMAN Penny **2013- 2014**	STFC	UK

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