Horizon 2020
Work Programme 2018-2020

Recommendations from Expert Advisory Group on European Research Infrastructures Including e-Infrastructures

1st June 2016
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Introduction

The Horizon 2020 Advisory Group on European Research Infrastructures including e-Infrastructures was convened by the EU Commission on the 26th February 2016, and the Chair Prof Luis Magalhães (Professor at IST - University of Lisbon), Vice-Chair Dr Sanna Sorvari (Research Manager at Finnish Meteorological Institute) and Rapporteur Dr Sandra Collins (Director of the National Library of Ireland) were appointed in agreement with the Group. This is the second iteration of the Expert Advisory Group and it was charged to address the key challenges facing Research Infrastructures, and to make viable, tangible recommendations to support EU competitiveness and leadership in the area of Research Infrastructures for the Horizon 2020 Work Programme of 2018-2020.

Research and e-Research Infrastructures are an essential enabling and underpinning component to the delivery of the Digital Single Market Strategy and the 'Open Innovation, Open Science and Open to the World' agenda. (e-)Research Infrastructures are essential infrastructure to carry out basic, applied and innovation-ready research across multiple domains and multi-disciplinary areas. Additionally, particular policy and strategic drivers which would be addressed by enacting the recommendations of this group include the Digital Single Market Strategy, Digitising the European Industry and the European Cloud Initiatives, the New Skills Agenda for Europe and the e Government Action Plan.

During the meeting in February 2016 the group identified four major themes essential to consider for the development of (e-) Research Infrastructure, and the group established subgroups to address these themes as follows:

- Internationalisation, with subgroup chair Beatrix Vierkorn-Rudolph
- Lifecycle, with subgroup chair David Bohmert
- Data, with subgroup chair Juan Bicarregui
- Innovation, with subgroup chair Sergio Bertolucci.

The four subgroups each produced a substantial report addressing the five questions as set-out by the European Commission, and this synthesis report, which is written by the Chair, Vice-Chair and Rapporteur of the Expert Advisory Group summarises the key findings of the four subgroups. The four reports are included in their entirety as appendices to this synthesis report, which was sent to all Expert Advisory Group members to allow taking into account final comments before submission.

Following in-depth discussion and investigation during the period February – June 2016, including a second meeting on 19th May 2016, the group consensually agreed on the key points as laid out in summary in the following pages in response to the five questions as set-out by the European Commission.
1. What are the challenges in the field concerned that require action under the Work Programme 2018-2020? And would they require an integrated approach across the societal challenges and leadership in enabling and industrial technologies?

International cooperation improves excellence in science and raises new opportunities for innovation and emerging economies. International RIs are the backbone of science and deliver excellent services for researchers and also for industry. They help to answer complex questions in the area of basic sciences and in application-oriented research by bringing together the necessary know-how and expertise on a broad scale and in a coordinated way. Complex RI often evolve from ideas and demands from scientific communities followed by a long process of strategic priority setting, planning and design – typically at national level, but increasingly also at regional and even global level. The participating countries may have major differences in R&I funding systems, and political, cultural and legal barriers have to be overcome to plan, construct and operate jointly RI. Countries which have not yet sophisticated procedures for strategic planning and evaluation processes may benefit from assistance by more developed countries via partnership processes. Implementation of efficient evaluation procedures of scientific excellence meeting ESFRI, the Group of Senior Officials (GSO) and OECD/GSF criteria should be promoted. Peer review should be mandatory for the evaluation of the setting-up of RI and the allocation of experimental time and use of archives, etc. Such peer review procedures could be included in the Statutes or the Articles of Association of each RI as a requirement for funding. Care should be taken to avoid an increase of the concentrations of RI in few European regions actually widening the gap with lesser performing regions.

The process to initiate new international partnerships in current national RI needs support (e.g. networking, follow-up, monitoring and other tools required to facilitate international partnership). The EAG encourages RI reaching out to third countries worldwide to develop access policies taking the European Charter for Access to Research Infrastructures¹ into account and to consider facilitating access for researchers from less developed countries.

Certified training for RI managers, including business and administration issues (especially cost-assessment and risk management), are urgently needed, as well as support for worldwide mobility of RI managers. Mentoring programmes for RI managers are important to ensure experience transfer, and sustain career development and progression. Staff exchange programmes are needed and have to be adapted to each type of RI.

Integrating and clustering activities effectively enabling cooperation amongst and integration and even mergers of existing Research Infrastructures are important for achieving synergies between existing RI. The integrating activities should not only address the Research Infrastructure per se, but also the far larger scientific user communities. An underpinning challenge is the absence of coherent and consistent application of definitions, concepts, models, road mapping, evaluation mechanisms, funding instruments and cost calculations, which can be addressed by policy alignment and

promotion of best practice, at both European and global levels. The feasibility of an agreed label for Regional Partner Facilities (RFP) allowing them to be linked to excellent RI should be investigated.

Research Infrastructures face challenges concerning long-term financial sustainability during their life cycle:

- the increasing reliance of the scientific communities on RI to produce excellence science is creating a stress on research budgets at national and European levels which was not fully anticipated;
- the ongoing concentration of excellent RI in limited regions is contributing to increase the innovation divide within the European Research Area (ERA) and between different regions in the world;
- while we may consider sufficient the current (primarily national) funding situation for the design, preparation and implementation phases, we find that Research Infrastructures face serious deficits in their operational sustainability.

There is a need to investigate the complementing of funding from national sources, complying with an internationally aligned lifecycle approach for Research Infrastructures and directed towards supporting the move towards implementation and operational sustainably. Funding should be made available in Horizon 2020 for flexible and targeted support to pan-European and international RI in all phases of their life cycle, and this support could be targeted towards specific issues such as assuring scientific coverage, establishment of data management implementation, integrating activities and support to promote access. Strategy-led and structuring approaches at European level to RI - such as ESFRI, the e-IRG, MERIL and GÉANT – should be supported.

Open data RIs should be conceived so as to be continuously enriched with the added value of secondary data and findings resulting from the respective primary data. This should be a requirement for users of such data to ensure increased value of the infrastructure along its life cycle and unleash the full benefits of the Open Data and Open Science vision.

The European Cloud Initiative Communication stresses the importance of being able to find, access, move, share and re-use data seamlessly across global markets and borders, and among institutions and research disciplines. Europe must overcome the remaining barriers. Achieving the ambitious vision set out of a European Open Science Cloud underpinned by a European Data Infrastructure will require a significant initiative with a suitable and solid funding model centred on data at national, regional and global levels, with three pillars:

- Culturally, there are changes needed to make all scientific data produced by the Horizon 2020 programme open by default and to raise awareness and change incentive structures for academics, industry and public services to make data publicly available while at the same time respecting concerns in relation to privacy and ethics (e.g. for medical data), safety, security and commercial interests, whilst acknowledging the legitimate concerns of private partners (data security, intellectual property, copyright etc.). From a legal perspective, action is needed to define and set new, adequate legal regulations.
- Technically, there is a need to develop specifications, standards and protocols for making data available, for interoperability and data sharing across disciplines and infrastructures and to develop, for example, cloud based services for open science supported by or supporting the necessary data infrastructure, as well as software focused on e-research, e.g. virtual
research environments, research data management, access security, authorisation and authentication, interoperability, etc.

- **Geopolitically**, there is a need to enlarge the scientific user base to researchers and innovators from all disciplines and all regions and to create a governance structure to federate scientific data infrastructures and overcome fragmentation. Action is needed to federate the existing (national) data infrastructures.

In particular, there is a need to develop specifications, standards, protocols and infrastructure that support data discovery by exposure of metadata. The infrastructure for this (hardware and software) has also to ensure data security (authentication and authorisation etc.) in order to exclude misuse even tracking of a retrieval process. There also is a need to develop data quality, integrity and transparency criteria, as well as technical components and methodologies, as a basis for long term preservation of data and associated artefacts in their research context, and to insure these same properties throughout the whole data pipeline.

Demonstrating the fundamental role of RIs in the translation of Open Science into Open Innovation can be proven through the execution of **Innovation Pilot projects** to integrate RIs with industry, entrepreneurs and private investors in a co-development effort. Initiatives in this direction will provide a rich test bed to address many of the issues expressed in the report of the ESFRI Working Group on Innovation (March 2016), such as accessibility of RIs to industry, promotion of the innovation and industrial capabilities of the RIs, streamline of knowledge and technology transfer processes, etc. Moreover the pilots, if significant enough in terms of size, will allow testing quantitatively the combinatorial power of Open Innovation and the multiplication effect of the investment made on RIs in the creation of economical and societal value. These pilots should integrate bodies across disciplines, skills and enabling technologies and they would therefore greatly benefit in term of policies and efficiency from a similar integration of the actions supported by the EC DGs RTD, CONNECT and GROWTH. The pilots shall be characterized by a bottom up approach on homogeneous themes, chosen on the basis of their strategic potential to connect science, industrial leadership and societal challenges. The scope of the pilots should focus in the streamlined integration of the various actors and the test of sustainable models enabling the exploitation of the whole value chain from fundamental science to the market, and the calls should rely on clear and tangible performance indicators for the pilots.
2. What is the output/impact that could be foreseen? Which innovation aspects could reach market deployment within 5-7 years?

International cooperation stimulates innovation and RI-industry cooperation, and this could be supported by specific measures like international University–Research Infrastructures exchange programmes and the provision of customized services for increasing the participation particularly of SMEs and industry users and partners, and specific access modalities and business models for industrial use of RI may need to be developed and evaluated.

Since internationalisation means in many cases also a change in scale/size of all measures and procedures for competitive and excellent science production, a specific support action might be useful to assist the actors in such a changing environment to act in an effective and best possible way.

An important aspect is the improvement of the international accessibility of data and research information generated in the RI for user communities in different research organisations and in a variety of research fields addressing global issues; data sharing models also enable industrial exploitation but care should be taken to balance IP rights of both industrial users, the RIs and academic technology providers.

The added value at European level and the scientific output and efficiency of Research Infrastructures should be measured to better understand how outputs create jobs, boost sustainable economic growth, generate innovation, and help address global societal challenges. Attention is needed for better understanding and decision-making concerning the end of lifecycles in the framework of the broader RI ecosystem - e.g. integration, merger and update/upgrade, closure and dismantling. Addressing the lifecycle is critical because this establishes criteria and evaluation procedures at European level, which can also be applied at national/regional level, which should avoid unilateral closure without a plan to re-invest.

The participation of business, industries and public services in RI varies across the different phases of the lifecycle and overall should be promoted and increased through co-funding mechanisms. To reach market deployment within 5 to 7 years requires continuous and well proven collaboration schemes with industry, particularly in the construction phase and the upgrades. Moreover, collaboration schemes and models need to be financially supported at the very initial stage. A powerful instrument to stimulate the collaboration would be joint PhD research projects co-funded by industry, university and the specific RI under some EU scheme requiring these 3 actors. It could be of interest to consider some Marie Curie support or a support to RI requiring setting up a research programme with industry and university. Collaboration schemes enabling the mobility of personnel between Research Infrastructures and industry would be beneficial. Service-orientation of RI (eventually via a virtual market place) should be stimulated and systemic and independent assessment mechanisms be promoted. New RI involving development of innovative technology may provide unique opportunities for high impact innovation either within partnerships with industry or well-conceived pre-commercial procurement.
The advent of Open Science will transform the way research is conducted, and open data is a key enabler of this change. Better scrutiny of research processes will trigger faster evolution of hypotheses and methodologies. Greater sharing of the supporting IT, including both hardware and software resources, will lead to higher quality and more efficient usage of those resources. Enhanced ease of use will enable broader participation across scientific community and scholars from different countries, from industrial players, in particular lowering barriers to entry for SMEs and other users. It is likely that all these changes will begin within 5-7 years. In particular, the exploitation of research data for other uses by entrepreneurs who see new applications can happen very quickly once the data is available, but it is very difficult to predict which data will be the source of such innovation.

Actions are required to harmonise data policy, address data ownership and data privacy, deliver data training and education curricula, ensure implementation of best practice in all aspects of data management (including in respect to discoverability, accessibility, intelligibility, assessability, interoperability, curation, preservation), particularly by supporting regional and global initiatives that work on standardisation and promotion of best practice such as RDA, CODATA and W3C, and addressing gaps in responsibility between funders, institutions, private sector and researchers.

Within the timeframe of 5-7 years, the proposed Innovation Pilot Projects are anticipated to lead to new high performance materials, devices and systems, advanced manufacturing and production processes, and to streamline the transition of breakthrough technologies towards the market related to paradigms like the Internet of Things, health care, Intelligent Transport, Sustainable Energy and Resources and Big Data, and lead to new opportunities for industry, young entrepreneurs and SMEs including micro SMEs.
3. Which gaps (science and technology, innovation, markets, policy) and potential game changers, including the role of the public sector in accelerating changes, need to be taken into account?

At international level, gaps between potential RI partners are of various types: political and legal/regulatory systems, different levels of technology readiness, and economic development. Funding gaps and gaps in the scientific coverage of various scientific areas also have to be considered. A pilot landscape and gap analysis in the field of RI was conducted by ESFRI at EU level for the roadmap update 2016 and will be continued. The inclusion of non-EU members (including the main strategic partners of Europe) in landscape analyses would be necessary to better understand the gaps. Involving new countries in RI through international cooperation can increase science excellence and broaden the international coverage of data, in particular in environment, energy and life sciences. The involvement of more countries can bring in new skills, knowledge and resources, but the right tools to improve and facilitate this involvement have to be developed and should encompass existing complementarities and open access models.

To assist the incubator role of RI for innovation, a support measure for promoting/establishing joint PhD programmes between industry, Research Infrastructures and universities should be considered. This could help not only to make industry more aware about the possibilities RI offer, but also to allow PhD students to be more aware of related career paths.

The relationships between RI access polices and business models needs to be clarified. Co-funded fellowships to build relationships between Research Infrastructures and business-oriented schools/faculties to promote RI managers education and training would be an enabler.

Whilst incremental progress of scientific research is well supported through current mechanisms at the Member State and European levels, there is often a lack of appetite for truly transformational research by comparison with other regions where more risky developments that explore new areas and try out new methods can be funded via foundations, risk-capital, etc. To stay competitive in the long term Europe must be willing to undertake high risk research in both public and private sectors and avoid these activities being “outsourced” to other continents. The EC and Member States must incorporate opportunities for research with transformational potential in their funding schemes in order to remain at the leading edge in an environment where time to market is getting shorter. Support should therefore be provided for risk taking data entrepreneurs as well as larger and longer time framed data research with transformational potential.

The role of public funding in accelerating changes is vital: public funding is the principal agent capable of absorbing early stage risks associated to breakthrough technologies and forward-looking initiatives, creating in this way a path for the ingress of private investments. The role of private investments is then to generate the multiplication factor of public investment, and this should be demonstrated in the proposed Innovation Pilot Projects.

The compliance with Responsible Research and Innovation principles should be sought in all actions.

The avalanche of data arising from new and richer data source opens many opportunities for increasing the amount of data driven research undertaken in both public and private sectors. Europe needs more data and data curation professionals, skilled in current data analysis techniques and well
prepared to absorb techniques yet to be discovered. Also it is needed support for developments of new methods of data analysis and for providing education and training in these techniques.

4. Which areas could benefit from integration of horizontal aspects such as social sciences and humanities, responsible research and innovation, gender aspects, and climate and sustainable development?

The international development of distributed RI in the humanities as well as in the social, biological and environmental sciences is essential for the broad coverage of different cultural environments, lifestyle habits and geographical zones, which is required to broaden the observational, experimental, analytical, descriptive and data base infrastructures needed to answer the big questions in health, energy, the environment (and more). Challenges include the lack of common tools for integrating and using data produced by different RI, especially if working in different disciplines, and the lack of funds/instruments for integrating activities. Internationalisation of RIs could also facilitate analyses of the socio economic and gender factors related to changes in the labour market. The gender nature of migration is not fully understood, but RI collaboration could provide important insight into the changing European population and societies, its challenges and opportunities.

Most of the horizontal aspects play an important direct role in RI, actually leading to the awareness that RI themselves truly concern a horizontal aspect to all other research and innovation activities. Research Infrastructures have not benefited enough from integration across Horizon 2020. In humanities, social sciences and cultural heritage many activities are based on regional and national institutions and programmes should be setup to foster RI collaborations between these institutions at European level. Such collaborations would enhance our understanding of the contemporary, dynamic, gendered socio economic context across Europe and provide insight into the differential and intersectional experiences and social, cultural and economic resources of men and women including in employment, future of professions, personal and career development, collective organization, well-being, migration. Research Infrastructures produce knowledge directly relevant to understanding global societal challenges such as climate change and sustainable development. Integrated research programmes encouraging synergies between research conducted in the relevant RI are missing. Collaborative actions with Joint Programming Initiatives and integrative activities and thematic clustering activities can enable RIs to better tackle societal challenges and should be supported.

Access to RI and data stewardship – where appropriate – should become eligible costs for all research and innovation activities.

Mobility instruments and training and education initiatives are essential enablers. There is a need to build the RI human resources capacity including an improved representation of women and minority groups, involved in the integrating and training aspects, increase of exchanges, involvement of user communities, including industry.

The cultural changes required to truly achieve Open Science are significant and analysing them from a social sciences and humanities perspective would help effect the changes as quickly and efficiently
as possible. Further the growth in data driven science will lead to a huge shortage of data professionals in the near future unless there is a very significant increase in the training of data scientists. Meeting this need can be helped by actions targeted at establishing a gender balance in this domain.

The proposed Innovation Pilot Projects should include RIs from all scientific areas, business, innovation, gender and social science specialists, not only in order to facilitate the transition from an idea to the market and to provide tools and guidance to young entrepreneurs, but also to perform a continuing in-depth assessment of the progress and of the trends of the pilots. Moreover, the integration of horizontal aspects will draw attention to the gender societal challenges and innovative solutions that access to RIs, integrated across national borders, will lead.
5. While staying within the limit of the RI Specific programme, how can be the new policy initiatives such as the 3O's, the Digital Single Market (DSM) with the European Cloud Initiative, as well as the ESFRI Roadmap and the Long Term Sustainability of Research Infrastructures fully taken into account in the Work programme 2018-2020?

International organisations and fora such as OECD/GSF, ESFRI and GSO play an important role in the internationalisation of RI, as well as research organisations like EIROForum and Science Europe. The involvement of more partners is in many cases crucial, especially for the long term sustainability of RI. The involvement of less-developed countries and regions (in particular as regards sustainable development, environmental and energy projects) will contribute to widening participation and spreading excellence. International research Infrastructures have an important role in promoting and maintaining responsible innovation, including best practices for collaboration between RI. Gender engagement in projects should be evaluated with the aim of improving infrastructure usage.

A seal of excellence from a credible and recognised authority leveraging substantially more funding from the European Structural and Investment Funds (ESIF) and the European Fund for Strategic Investments (EFSI) into RI would promote trust and broader use of Research Infrastructures.

The systematic introduction of data management plans for RI should lead to sustainable solutions for the collection, handling and accessibility of data, but continued effort is needed to provide the appropriate tools for data management and accessibility of data to a broader international user community of RIs. The consideration of data, and data infrastructure, as a valuable and shareable resource should be required in all new projects in the RI programme. Open data is already the default position and now open science, including sharing of data-infrastructure, software and methodologies, is the next step. All this will lead to realize the European Science Cloud (EOSC).

Balancing top down and bottom up approaches will certainly speed up the process of creation of trust and of a shared innovation culture, which are necessary ingredients for the establishment of an innovation ecosystem. Long-term sustainability of RIs can only be ensured if Europe continues to develop cutting-edge technologies and has industrial companies able to build them. The increasing size and cost of RIs imply large fluctuations in time for the construction and operation phases, what can dissuade industrial companies of participating. The sharing of information, pooling of resources, coordination of R&D activities, and access to fabrication, assembly and verification platforms is therefore essential and should continue to be funded by public investment in-between large-scale project construction.

Open Innovation is a complex principle, for instance in what relates to the traditional business practice of keeping and valorising Intellectual Property. That conflict also exists for Research Infrastructures, as many of them are encouraged to seek revenues from their Intellectual Property development, what can limit open access to innovation. So, new models of innovation development and funding for RIs should be put in place to allow for compatibility with the Open Innovation principle.
Concluding Remarks

Research and e-Research Infrastructures are an essential enabling and underpinning component of the overall European research area and important contributors to the delivery of the Digital Single Market Strategy and the 'Open Innovation, Open Science and Open to the World' agenda. In addition, Research Infrastructures and e-infrastructures are the backbones and necessary environments for research and innovation to tackle societal challenges.

In this synthesis report the Advisory Group identified several strategic points, such as:

- **Life-cycle approach**: When setting up world-leading and vital Pan-European research infrastructure landscape the whole life-cycle of RIs should be taken into account by supporting all the steps of the RI evolution, especially when bottlenecks appear (e.g. by supporting the integrating and cluster activities, planning and implementation of the carefully pre-selected RIs and the operational challenges of RIs, especially when adjusting/redirecting services or in decommissioning phase).

- **Coordination and harmonisation actions**: To succeed in setting up a coherent RI landscape, EC should continue to support coordination and harmonisation actions on definitions, concepts, assessment mechanisms, funding and cost models, access policies, etc., not only promoting the alignment of processes and concepts at national and European levels, but also promoting the European RI framework and broadening international cooperation.

- **Global leadership**: Europe should aim at global leadership in Research Infrastructures; there is a clear European added-value opportunity in supporting such efforts.

- **Overcoming cultural, technical and geopolitical challenges**: The EU Commission ambitious effort regarding the European Open Science Cloud is most welcome, but it should be realized that there are many associated cultural, technical and geopolitical issues that need to be tackled with appropriate support to ensure the transition and reorientation of e-infrastructure landscape and data related services in Europe and internationally.

- **Lead in innovation related with RIs**: As RIs can act as incubators for innovation, consider the design and support of an innovation pilot project to further develop the conditions for collaborative work of science, business and industry, and to support the emergence of young entrepreneurs related to RIs.

- **Education and Training**: Develop education and training opportunities for and with RIs of data scientists and curators, RI managers and technicians, RI prospective users from academia or business, as they are necessary for Europe to achieve the leadership position in science and innovation and to meet the associated societal challenges.
We also call attention to the need of continuing to address cross-cutting issues identified by the Advisory Group with the initial membership, as, due to their nature, require continued effort, namely:

**Access:** Mechanisms to enable transnational access to research programmes and infrastructures and to support access for remote communities to research infrastructures and services.

**Funding:** Enable and leverage a blend of multiple funding sources (H2020, regional, national, cohesion, PPP, other) for diversified long-term funding for research. Involve European, national and regional funding agencies in joint programmes and actions.

**Engagement:** Exploit best user/stakeholder engagement and foster the engagement of researchers, research organizations, industry and citizens.

**Exploit existing strengths:**
- Re-use existing best research infrastructures and data management methodologies, tools and technologies, and engage in international cooperation for best practice in data sharing;
- Develop an Open Market Place for research services, via a user-driven registry or distributed catalogue of services offered by research service providers;
- Support the further development of methods for discovering scientific knowledge, coming from machine learning, data mining, and intelligent data analysis.

**Trust and Accountability:**
- Strengthen accountability and both ex-ante and ex-post evaluation practices;
- Increase emphasis on trustability and interoperability in research and research tools;
- Support the definition of a clear and effective techno-legal framework allowing for responsible scientific research to foster whilst taking account the interests of the data subjects.

**Strategy:** At all levels, pursue strategic planning and road-mapping to support contributing to innovation and to grand societal challenges, and to promote their visibility.

**Horizontal nature:** Foster actions involving multiple disciplines (in particular, with better linking social sciences and humanities with other research areas), multiple roles, diverse experiences, basic and applied research.

**Leadership:** Aim at world example and leadership in science and innovation, standing on European openness, diversity, and strengths. Strengthen strategic international cooperation in research.

Luis Magalhães, Chair
+Sanna Sorvari, Vice-Chair
Sandra Collins, Rapporteur
ANNEX 1 - Internationalisation Subgroup

David Boehmert, Corinne Borel, Sabine Bruenger-Weilandt, Lucie Guibault, Milan Macek, Luis Magalhães, Blanca Miranda Serrano, Jean Moulin, Monica Silenzi, Sanna Sorvari, Beatrix Vierkorn-Rudolph (chair), Peter Wittenburg

1. Task from the European Commission

The European Commission has set up various Expert Advisory Groups to accompany the successive batches of the funding under Horizon 2020 from 2014 to 2020.

RI play an ever increasing role in research funded by the European Commission since they are:

- unique instruments to better organise and carry out top-level research all over Europe;
- important to make research more cost-efficient and more competitive on an international scale;
- the instrumental backbone of the European Research Area (ERA);
- very efficient drivers for economic growth and welfare in Europe.

The subgroup “Internationalisation” has been asked to provide input for this issue in particular because RI play an important role to help society to face Global Challenges such as securing energy supplies, global warming, tightening supplies of water and food, securing quality of life for an ageing population and the gendered implications of these global challenges Many of these challenges can nowadays only, or at least better, be tackled in international cooperation.

The subgroup has been asked to provide input for answering the following questions:

2. What are the challenges in the field concerned that require action under the Work Programme 2018-2020? And would they require an integrated approach across the societal challenges and leadership in enabling and industrial technologies?

➢ Why is internationalisation of RI important and necessary?

International cooperation improves excellence in science and raises new potential for innovation and emerging economies. International cooperation and exchange - especially if this goes along with the opening/upgrading of national RI to the international level and transforming a national-borne effort into an international one – could help to raise evaluation/quality standards. International RI are the backbone of science and deliver excellent services for researchers and also for industry. They help to answer complex questions in the area of basic sciences and in application oriented research (including scientific support to public policies) by bringing together the necessary know-how and expertise on a broad scale and in a coordinated way.

These RI (single-sited, distributed across different countries or virtual) are often expensive; not only due to high initial investments, but also since long-term funding for their operation is required. The
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Economic crisis in Europe and in other advanced economies is putting funding for research and also for RI under pressure. This is another strong (financial) reason to join forces.

- **What are the challenges of internationalisation?** In terms of different legal/ political/ cultural contexts, funding systems for RI, decision making processes for RI (e.g. timeline, roadmaps, evaluations, strategic areas), widening participation

Complex RI often evolve from first ideas and demands from the scientific communities followed by a long process of strategic priority setting, planning and design – typically at national level, but increasingly also at regional and even global level. The potentially participating countries have major differences in R&I funding systems. Therefore political, cultural and legal barriers have to be overcome to plan, construct and operate jointly RI.

To realise international funded RI, compatible funding instruments and measures have to be identified, best practices of decision making, common strategic planning and evaluation procedures are further important steps for realising enhanced international cooperation for RI.

The improvement in terms of excellence in aspects ranging from science to knowhow transfer and knowledge increase, to innovation and education for international RI should be convincingly described encouraging Ministries and Funding Agencies to set up such RI.

Countries which have not yet sophisticated procedures for strategic planning, evaluation processes e.g. may need assistance by more developed countries to further shape and up-grade their R&I system. The various players at international level have at present different definitions, concepts and methods. Therefore, alignment of these and the implementation of efficient evaluation procedures of scientific excellence according to ESFRI, the Group of Senior Officials (GSO) and OECD/GSF criteria should be promoted. Peer review should be mandatory for the evaluation of the setting up of RI and the allocation of experimental time, use of archives e.g. Such peer review procedures could be included in the Statutes or the Articles of Association of each RI as a requirement for funding.

It should be avoided that the necessary requirements lead to an increase of the concentrations of RI in few European regions actually widening the gap with lesser performing regions.

**We recommend:**

- **Set up measures to assist interested countries in developing procedures for strategic planning, evaluation processes e.g.**
- **Propose partnership processes (H2020 teaming and twinning) for the above mentioned RI**
- **Possible problems and opportunities: see especially GSO or OECD/GSF policy areas (access, evaluation, data access and management only in view of internationalisation)?**

International cooperation of RI has been identified as an important issue and was discussed within several organisations like OECD/GSF, EIROForum, and ESFRI. Considering the already existing international cooperation of some scientific communities, the potential for more cooperation on issues related to Global Research Infrastructures (GRI) has been recognised by the Carnegie Group since 2007. At the first G8 Ministerial meeting, held in Okinawa on 15th June 2008, it was decided to establish a Group of Senior Officials for RI (GSO) to take stock and explore cooperation on GRI. In
2015 the GSO presented its first Progress Report to the G7 Science Ministers. Together with the Progress Report GSO presented for the first time a list of GRI (national or European RI open to further international partnership).

On the basis of the list the GSO conducted a survey about expressions of interest in the member countries of the GSO. GRI which would like to stay for longer time on the list have to fulfil the GSO framework criteria. Currently GSO is conducting case studies in a subset of five GRI of the list which present different types of GRI. These case studies aim to approve the GSO framework criteria and initiate new international partnerships on a broad scale. The GRI list is not limited to the member countries of GSO since GSO cooperates especially with ESFRI and also with OECD GSF on policy areas for GRI.

Concerning access a global excellence-driven access (gEA) quota was suggested, which means that GRI should offer a certain quota for gEA independent of financial contribution to the respective GRI. G7 Science Ministers supported this concept and asked for further development of the concept in a qualitative manner for further implementation. G7 Science Ministers also asked for continue exploring the potential of existing RI to be opened to international partners on the basis of existing legal structures. And they encouraged the GSO to continue their work on convergence and alignment of inter-operable data management that could accomplish an effective open-data science environment at the G7 level and beyond. Engagement with RDA should be continued.

- What actions are required under WP 2018 – 2020? (further support from COM of the GSO work)

The process to implement the GSO recommendations and to initiate new international partnerships in current national RI has started. Whether the present GRI on the GSO list will meet the GSO framework criteria will only become apparent in future. This process takes some time and needs support (e.g. networking, follow-up, monitoring). If the outcome of the case studies will be that the framework is sufficient for selecting appropriate GRI, the next step should be to decide how the involvement of further countries will be possible. Since GSO cooperates closely with ESFRI and most of the GSO delegates are also delegates of the ESFRI Forum, it should be reasonably easy to address this issue. In addition, GSO also closely cooperates with OECD/GSF, so that also international cooperation could be supported in principle. In order to effectively contribute to tackling the Grand Challenges and to enable RI to support science diplomacy, flexible and targeted support to GRI is needed including the tools required to facilitate international partnership. The EAG encourages RI reaching out to third countries worldwide to develop access policies taking the European Charter for Access to Research Infrastructures into account and to consider targeted access opportunities to tackle gender aspects and facilitating access for researchers from less developed countries.

To support further the international cooperation some issues should be addressed:

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2 Framework criteria of GSO (annex 1)
better understanding of the international landscape of RI (ESFRI has set up a process to analyse the landscape of RI and also OECD/GSF is working in this area),

- analysing more deeply the challenges of international RI in terms of governance, management, funding, legal aspects including issues like know how and data protection, public security, corporate and tax law e.g..

We recommend:

- Depending on the outcome of the case studies, the criteria of the framework could be used for further RI to be opened to international cooperation. In this context some support for developing partnerships between countries (including EU countries not directly involved in the GSO) would be helpful.

- Further certified trainings including business and administration issues (especially cost-assessment and risk management) for RI managers are urgently needed including worldwide mobility for RI managers. Moreover, there is a need for targeted training and recruitment of under-represented groups including women to improve the human resource capacity of RIs. RAMIRI evaluation in terms of efficacy would be the first step before starting new training measures.

- Mentoring programmes for RI managers are important to encourage career development and progression.

- Staff exchange programmes have to be adapted on the type of RI means that they need to allow flexibility for the individual RI.

3. **What is the output/impact that could be foreseen?**

Which innovation aspects could reach market deployment within 5-7 years?

International cooperation not only improves the use of resources due to broader cooperation and consultation on the international level. It also generates higher visibility of European RI and could broaden the range of users. Moreover, it will increase the scientific support to public policies at international level and to better face together the societal Global Challenges. And it stimulates innovation and RI-industry cooperation, from the concept/design and construction of RI until operation. This effect could be supported by specific measures like international university-RI exchange programmes and also PR measures which demonstrate the usefulness of RI for different research disciplines, applications or also citizen science. The provision of customized services for increasing the participation particularly of SMEs and users should be encouraged. Comprehensible successful cases of how a good symbiosis between RI service providers and R&D users (research organisations and industrial enterprises) can be established should be analysed and used as best practice for the others.

For generating solutions for global challenges, also the broadening of the usability for international industries in terms of “open innovation” is desirable. To achieve this, specific access modalities for industrial use of RI has to be developed.
An important aspect here is also the improvement of the accessibility of data and research information generated in the RI for user communities in different research organisations and in a variety of research fields addressing global issues.

Since internationalisation means in many cases also a change in scale/size of all measures and procedures for competitive and excellent science production, a specific support action might be useful to assist the actors in this changing environment to act in an effective and best possible way.

Also business model variants (taking into account funds and sponsoring) by involving potential users from science and industry should be developed and offered for testing and evaluating for wide usage in case of common agreement about their applicability.

Open data models could increase industrial interests of exploitation but has on the same time ensure IP rights of both sides, for industry as well as for the RI.

Furthermore access for the international community to excellent RI would contribute to widening participation.

4. Which gaps (science and technology, innovation, markets, policy) and potential game changers, including the role of the public sector in accelerating changes, need to be taken into account?

At international level, gaps between the potential partners are of various types: political and legal/regulatory systems; different levels of S&T development, economic development.

Furthermore funding gaps and the scientific coverage of various scientific areas has to be taken into account: A pilot landscape and gap analysis in the field of RI was conducted by ESFRI at EU level for the roadmap update 2016 and will be continued. The inclusion of non-EU members (the main strategic partners of Europe) in Landscape Analysis would be necessary to get a better view on the gaps.

A broad participation of at least as many European Member States /Associated Countries as possible and an increased international participation in social surveys are gaps to be filled to reach scientific excellence for data analysis. Involving new countries in RI through international cooperation can increase science excellence and broaden the international coverage of data especially in environment, energy and life sciences. The involvement of more countries can bring in new skills, knowledge and resources but the right tools to improve and facilitate this involvement have to be developed.

- To assist the incubator role of RI for innovation, support measure like promoting/establishing joint PhD programmes between industry and RI-universities should be aimed for. This could help not only to make industry more aware about the possibilities RI offer, but also to make PhD students aware of a possible career path.

- Develop tools to increase collaboration with new countries, in particular, to fully use the existing complementarities between the various partners. This process should rely on a sound landscape and gap analysis. The issue of open access is here also a critical factor of success.
5. **Which areas could benefit from integration of horizontal aspects such as social sciences and humanities, responsible research and innovation, gender aspects, and climate and sustainable development?**

The areas Health, Energy and Environment are of global relevance and therefore need international cooperation for developing solutions.

In distributed RI in the social, biological or environmental sciences the international dimension is a key factor due to the broad coverage of different climate zones, cultural environments, lifestyle habits that is required and which could lead to broadening the observational, experimental and data bases. SHARE-ERIC for example is part of a worldwide network of studies of aging. International cooperation allows in this case unique possibilities of comparison of the results, which play an important role for scientific analysis and political consulting. The same is true for the distributed observational facilities. One problem which has to be tackled is the lack of common tools for integrating and using data produced by different RI especially if working in different disciplines. Also the lack of research funds for integrating activities is a big challenge.

The increasing internationalisation of RIs should also be focused on the socio economic and gendered factors relating to changes (including technological and migration) in the labour market, the nature of professional work and impetus from open RIs for the setting up of SMEs. The gender nature of migration is not fully understood but RI collaboration could provide important insight into the changing European population, its challenges and opportunities.

6. **While staying within the limit of the R1 Specific programme, how can the new policy initiatives such as the 30's², the Digital Single Market (DSM) with the European Cloud initiative⁴, as well as the ESFRI Roadmap and the Long Term Sustainability of Research infrastructures be fully taken into account in the Work programme 2018-2020?**

ESFRI plays an important role in the internationalisation of RI (at least for the ones on the ESFRI Roadmap). Other key players are OECD/GSF or GSO as well as research organisations like EIROForum and Science Europe. Consequent pursuing the principle of the 3 O’s (open innovation, open science, open to the world) could help to involve more partners. The involvement of more partners is in many cases crucial, especially for the long term sustainability of RI.

The involvement of lesser performing countries and regions (in particular as regards sustainable development, environmental and energy projects) will contribute to widening participation and spreading excellence.

The systematic introduction of data management plans in RI which should lead to sustainable solutions for the collection, handling and accessibility of data - taking into account data safety and data protection requirements(e.g. in the medical area) - should be further promoted within the RI. This facilitates not only the sharing of data among the users of a given facility but also the use, re-use and interoperability for user of other disciplines and institutions. A real effort is needed to provide the appropriate tools for data management and accessibility of data to a broader international user community of RI.
Global research Infrastructures also have an important role in promoting and maintaining responsible innovation, including also partners from outside Europe and to provide best practices for better collaboration and reaching synergies between RI. Moreover, the gender engagement in projects should be evaluated with the aim of improving infrastructure usage.


ANNEX 2 - Lifecycle Subgroup

Juan Bicarregui, David Bohmert (chair), Irena Kotowska, Blanca Miranda Serrano, Marek Niezgódka, Caterina Petrillo, Sanna Sorvari, Rosette Vandenbroucke (representing Sverker Holmgren, eIRG Chair), Lajos Balint, Peter Wittenburg

1. What are the challenges in the field concerned that requires action under the WP 2018-2020?

   Regional, national and pan-European RI are confronted with a variety of challenges at various levels:

1. The development of RI in all domains of research and the increasing reliance of the scientific communities on RI to produce excellence science is creating a stress on research budgets at national and European level, which was not fully anticipated.

2. RI face challenges concerning their long-term (financial) during their life cycle: while the current primarily national funding for the design, preparation and implementation phases overall seems sufficient and increasingly aligned for pan-European RI, RI face serious challenges during their operation phased as to date, the EU does not allow for supporting RI operation and national funding is faced with increasingly large RI portfolios essential for the production of excellent science in all scientific domains. Moreover, also the funding for RI from the EU Framework Programme for Research and Innovation (Horizon 2020) is very limited and has moreover undergone substantial cuts in the last years.

3. There is a continuous need to imbed national super advanced communities within cooperation and competition at international level.

4. The concentration of excellent RI in limited regions is ongoing contributing further to the increasing innovation divide within the European Research Area (ERA) and between different regions in the world.

5. There is a lack of qualified managers of RI (including an under-representation of women) leading to inefficiency in the management of some RI. Moreover, RI often face serious difficulties in the management of the so-called interim phase directed toward gathering the final commitment of all stakeholders.

6. The non-alignment of definitions and concepts, road mapping and evaluation mechanisms, funding instruments and cost calculations delay and hamper the smooth and sustainable development, implementation and operation of RI.

We therefore recommend:

- Coherent and consistent application of definitions, concepts, models, road mapping, evaluation mechanisms, funding instruments and cost calculations need to be promoted and further aligned, also at international level.
There is a need to investigate the complementing of funding from national level complying with an internationally aligned lifecycle approach to RI directed towards supporting the development of RI to move towards implementation and operate sustainably. Funding should be made available in Horizon 2020 for flexible and targeted support to pan-European and international RI in all phases of their life cycle. This support could be targeted to certain issues, such as assuring scientific coverage, establishment of data management, integrating activities and support to promote access.

The feasibility of a label for Regional Partner Facilities (RFP) allowing them to be linked to excellent RI should be investigated.

The integrating activities effectively enabling far going cooperation amongst and integration and mergers of existing RI deserve more importance. They seem key in realising synergies between existing RI. The integrating activities should not only address the RI owners, but also the far larger scientific communities behind the RI. Integrating activities therefore should aim at the RI users and the communities they belong to, in order to foster a culture of cooperation and integration. Integration of methods, procedures, techniques and services among the RI themselves is easier and it serves the purpose of optimising costs, but it addresses the surface of the problem. Structuring actions, that are so effectively brought in and sustained by RI, need to be stabilised and further supported at EU level by addressing the problem of the integration of the RI users, to effectively maintain the changing vision in the way how science is produced.

ESFRI Projects and ESFRI Landmarks (following up on the evaluation and monitoring exercise in the framework of the ESFRI Roadmaps 2018 and 2020) need sufficient funding allowing for flexible and targeted support.

Strategy-led and structuring approaches at European level to RI - such as ESFRI, the e-IRG, MERIL and GÉANT – should be supported.

The further increase of the qualifications levels of RI managers is needed. There is a need to build the RI human resources capacity - including an improved representation of women involved in the integrating and training aspects, increase of exchanges, involvement of user communities, including industry.

2. What is the output / impact that could be foreseen?

In the light of the scarce public resources for RI and the lack of private investments into RI, they increasingly are expected to demonstrate the broader socio-economic impact:

7. The main and major impact of RI are to be found in science itself. However, due to a lack of systemic and independent assessment mechanisms and the drive of established institutions and organisations to preserve themselves, we currently lack insight and decisiveness in framing the RI landscape and its implications in the end of the lifecycle of RIs.
8. In order to effectively contribute to the solving of the grand societal challenges, RI need to increasingly operate at global level and thus offer opportunities for extension of partnerships globally and for science for diplomacy.

We therefore recommend:

➢ The added value at European level and the scientific output and efficiency of existing RI should be monitored, not least to better understand how the knowledge from RI is used to create jobs, boost sustainable economic growth, helps addressing the global societal challenges and generates innovation. Particular attention is needed to a better understanding and decision-making concerning the end of their lifecycles in the framework of the broader RI ecosystem – e.g. integration, merger and update, closure and dismantling – be promoted. Addressing the lifecycle is critical because this provides for criteria, evaluation procedures, etc. established at European level, which can be applied at national/regional level. It should contribute to avoiding that the closing down of an RI is adopted by national governments without safeguarding a plan for investing in other/upgraded/etc. RI, with the result of overall reducing the RI funding.

➢ Service-orientation of RI (eventually via a virtual market place) should be stimulated and systemic and independent assessment mechanisms be promoted.

➢ The participation of business, industries and public services in RI varies across the different phases of the lifecycle, from providers of services and goods (e.g. through procurement) to users. Overall, both the use of RI by business and industry and the investment of business and industry into RI should be raised. We point out to the potential of co-funding mechanisms in this respect. To reach market deployment within 5 to 7 years requires continuous and well proven collaboration schemes with industry, particularly in the construction phase and the upgrades. Moreover, collaboration schemes and models need to be drawn and financially supported at the very initial stage. A powerful instrument to stimulate the collaboration would be joint PhD research projects co-funded by industry, university and the specific RI under some EU scheme requiring these 3 actors. It could be some Marie Curie or some supported action directed to the RI and requiring setting up the research programme with industry and university. Further, collaboration schemes favouring the mobility of personnel between the RI and the industry should help.

3. Which gaps (science and technology, innovation, markets, policy) and potential game changers, including the role of the public sector in accelerating changes, need to be taken into account?

We identify the following gaps and game changes in the field of RI:

Regional, national and pan-European RI are increasingly viewed within the broader RI landscape and ecosystems.

RI increasingly need to improve their access policies and develop business models relying on multiple funding sources.
We therefore recommend:

- The relationships between access policies and business models of RI not least with a view on enforcing the role of RI in education and training needs to be better understood.
- The relationship between RI and business-oriented schools/faculties to promote RI managers education and training should be reinforced. Again this could be achieved through a fellowship programme supported by EU, co-funded and based on a collaboration RI-University oriented to PhD and Master Students.

4. **Which areas could benefit from integration of horizontal aspects such as social sciences and humanities, responsible research and innovation, gender aspects, and climate and sustainable development?**

Most of the horizontal aspects play an important direct role in the field of RI actually leading to the awareness that RI themselves truly concern a horizontal aspect to all other research and innovation activities. We feel that RI as horizontal aspect have not benefited enough from integration across Horizon 2020 and beyond. In the area of social sciences, humanities and cultural heritage many activities are based on regional and national institutions. Programmes should be setup to foster RI collaborations between these institutions at European level that go beyond the European goals. Such collaborations would enhance our understanding of the contemporary, dynamic, gendered socio economic context across Europe and provide insight into the differential and intersectional experiences and social, cultural and economic resources of men and women including migration.
We therefore recommend:

- Developing excellent European RI for 2020 and beyond is of highest importance for European science and the competitiveness of Europe. Therefore, the overall funding level into RI outside the WP for RI should be raised and clearly linked to the entire lifecycle of RI.

- Access to RI and data stewardship – where appropriate - should become eligible costs for all research and innovation activities.

- More funds should be spent on staff exchange amongst RI and with business and industry under the Marie Sklodowska-Curie Actions.

- A seal of excellence from a credible and recognised authority leveraging substantially more funding from the European Structural and Investment Funds (ESIF) and the European Fund for Strategic Investments (EFSI) into RI should be introduced.

- More funding for education and training at RI should be targeted under Erasmus+ and applications encouraged for under-represented groups.

- RI produce knowledge directly relevant to understanding global societal challenges such as climate change and elements related to sustainable development. What is missing are integrated research programmes that encourage synergies between research conducted in the relevant RI. Collaborative actions with Joint Programming Initiatives should be supported. Integrating Activities and thematic clustering activities also promote the RI contributions to tackle societal challenges.

- Similarly, horizontal integration of the social dimension is rarely done under current RI operation and could be promoted. Such promotion would help improve excellent socio economic research, provide greater insight into future gaps in RI programmes and enhance socio-economic and gendered understanding.

5. While staying within the limit of the RI Specific programme, how can the new policy initiatives such as the 3O’s2, the Digital Single Market (DSM) with the European Cloud Initiative3, as well as the ESFRI Roadmap and the Long Term Sustainability of Research Infrastructures be fully taken into account in the Work programme 2018-2020?

Complementing the above-mentioned conclusions and recommendations, we point towards the currently large and diverse project portfolio supported under the RI WP of the EU FP for Research & Innovation. In order to increase the effectiveness of the very limited resources within RI under Horizon 2020, the WP 2018-2020 needs further simplification and focus and should carefully balance between the funding of bottom up and top down – i.e. limited and pre-defined eligibility of proposals - initiatives. This should be done by better understanding the RI landscape and use strategic approach in framing the future RI landscape.
ANNEX 3 - Data Subgroup

Sergio Bertolucci, Juan Bicarregui (chair), Sabine Bruenger-Weilandt, Lucie Guibault, Irena Kotowska, Milan Macek, Sanna Sorvari, Rosette Vandenbergroucke (representing Sverker Holmgren, eIRG Chair), Peter Wittenburg

1. What are the challenges in the field concerned that requires action under the Work Programme 2018-2020? And would they require an integrated approach across the societal challenges and leadership in enabling and industrial technologies?

The Open Science - A global vision implemented at all levels

In recent years many policy statements across the globe have emphasised the importance of an open approach to research for accelerating science and fostering innovation[1]. In Europe, as part of the Digital Single Market Strategy for Europe, the European Cloud Initiative Communication stresses the importance of being able to find, access, move, share and re-use data seamlessly across global markets and borders, and among institutions and research disciplines.

Europe should now take further steps to implement this vision and overcome the remaining barriers. Achieving the ambitious vision set out of a European Open Science Cloud underpinned by a European Data Infrastructure will require a significant initiative centred around data at national, regional and global levels.

At the European level, the Communication on European Cloud Initiatives highlights cultural, societal, technical and geopolitical challenges where action is needed.

Culturally, there are changes needed to make all scientific data produced by the Horizon 2020 programme open by default and to raise awareness and change incentive structures for academics, industry and public services to make data publicly available while at the same time respecting concerns in relation to privacy (e.g. medical data), safety, security and commercial interests, whilst acknowledging the legitimate concerns of private partners (data security, intellectual property, copyright etc.). From a legal perspective, action is needed to define and set new, adequate legal regulations.

Technically, there is a need to develop specifications and standards for making data available, for interoperability and data sharing across disciplines and infrastructures and to develop, for example, cloud based services for open science supported by or supporting the necessary data infrastructure.

Geopolitically, there is a need to enlarge the scientific user base to researchers and innovators from all disciplines and all regions and to create a governance structure to federate scientific data infrastructures and overcome fragmentation. Action is needed to federate the existing (national) data infrastructures. Achieving these goals will require concerted action over a considerable period to achieve the objective that Open Science becomes an established norm.
Cultural aspects of research data

From the publication of papers to the publication of research

The publication of papers is fundamental in science for two reasons. Firstly, papers enable others to check the validity of research results and, secondly, they allow others to build on those results to develop new research and to generate new knowledge. The publication of papers is also currently used as a metric in the assessment of the quality of research and even of the researcher that, although important in the whole ecosystem of research, is distinct from process of scientific discovery. As we move from the publication of papers to the publication of the entire research process (including for example results, data, software and methodologies), we need to ensure that these three uses of publication all evolve in unison, without any one hampering progress with the others.

To meet this challenge there is a need for a significant culture change that dissociates the communication of research from the assessment of its value.

Enabling data sharing while recognising intellectual contribution

Many current data policies allow periods of exclusive use of data as a means of allowing data creators to gain academic credit through first publication of papers. These “embargo periods” are an admission of the fact that data publication is not currently given as much credit as publication of papers and this is a strong disincentive to data sharing that introduces significant delays to the free flow of data in research. In order to establish a culture of data sharing, where researchers as eager to publish data as they are to publish papers, the intellectual contribution of data creation or collection needs to be appropriately recognised, so that it becomes advantageous to researchers if others publish papers based upon the data they collected.

To meet this challenge there is a need to develop the means to recognise the contribution of all roles in the research process and establish valued career paths for data scientists. Data Stewardship with according principles and roles needs to be developed and established.

Technical aspects of research data

The cultural changes described above need to be supported by a technical infrastructure that supports data sharing so that the benefit of openness can accumulate. In line with G8 principles data needs to be discoverable, accessible, assessable, intelligible, reusable, and wherever possible interoperable. These principles are echoed in the FAIR principles and many other policy statements across the globe.

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4 G8 science ministers statement: London, 12 June 2013
https://www.gov.uk/government/publications/g8-science-ministers-statement-london-12-june-2013

5 The FAIR Guiding Principles for scientific data management and stewardship, Scientific Data 3, Article number: 160018 (2016), doi:10.1038/sdata.2016.18
Discoverability

Data is of no use if it cannot be found. Data can be discovered through its technical and discipline specific metadata or, in some cases, from direct searching of the actual data. Just as research literature can be found in many ways, so too can research data be discovered by a variety of means. Data can be made discoverable at source (c.f. institutional repositories), or records of the data can be collected in catalogues which then provide a “shop window” to promote the content (c.f. journals and thematic repositories), or data can be discovered through the use of general purpose search engines (c.f. web searching). At the present time, it is not clear which of these will be most effective for discovery of data so all avenues should be pursued until the relative strengths of each are known. Independence from shareholder value driven, global market players needs to be considered.

To meet this challenge there is a need to develop specifications, standards, protocols and infrastructure that supports data discovery by exposure of metadata. The infrastructure for this (hardware and software) has also to ensure data security (authentication and authorisation etc.) in order to exclude misuse even tracking of a retrieval process.

Accessibility, Intelligibility and Assessability

Once relevant data is found it needs to be accessed as easily and cost effectively as possible. Although there is clearly a global move towards openness of research data, differences in definition of openness exist that make access more difficult requiring data infrastructures to be more complex. Once data is accessed, it must be correctly understood which requires a lot of information about it to also be available. Furthermore, in order to assess the value of data recovered, it can be necessary to know many details about how that data was generated.

To achieve these goals of accessibility, intelligibility and assessability for data, these same properties need to hold of the whole data pipeline and the procedures that generated it. Then the publication of data becomes a simple, intrinsic step in a verifiable and open scientific process. It becomes as natural and to publish data in an open form as it is to store it locally. However this will require new tools and Infrastructure to support an open research process as well as to pick up and communicate publication events from disparate sources.

To meet this challenge there is a need to develop data quality, integrity and transparency criteria, as well as technical components and methodologies, as a basis for long term preservation of data and associated artefacts in their research context.

Interoperability

Even if we achieve data that is open within a field and recognition for data providers who form part of research teams in that field, there is currently little motivation for putting in additional effort to make data useful to other disciplines. Whilst interoperability across national boundaries is strongly motivated as disciplines are international, interoperability across disciplines, that is required to foster new cross-disciplinary research, requires some considerable effort and is less because of it’s novelty. The resulting data landscape will be complex and each step and each component needs to be built and tested, integrated, adopted, and evaluated.
To meet this challenge there is a need to build open core components, based on open specifications, where there is a proof of concept by prototypical software that is also open.

Geopolitical aspects of research data

Open to the world

The creation of knowledge is a global endeavour and research disciplines already work at global level. Greater openness must not limit cross border cooperation and legal frameworks must support the opening of data across geographic and political boundaries. International and interregional discussions at policy and technical levels need to continue to develop and promote guidelines and recommendations to overcome fragmentation, inefficiencies, etc. Policies and rules of engagement will be required that go beyond the G8/FAIR principles and that is linked globally into research communities.

To meet this challenge there is a need to involve experts from thematic areas and e-infrastructure provision together in global initiatives for standardisation like CODATA, RDA, W3C, as well as European and national initiatives.

Widening sources of data and user base

New embedded devices will in the near future be generating unbelievable amounts of data. The Internet of Things, cars, wearables, etc. are transforming physical objects into on-line data sources. This landscape of Big Data Analytics is still new and there are many opportunities yet to be seized. There is a need to foster “entrepreneurship” working alongside infrastructure provision to develop new types of services for data management that exploit the new availability of data. These may be stimulated by bringing entrepreneurs together research skills such as scientists, infrastructure experts, etc.

On the other hand, these new data sources raise serious concern about privacy and security that become significant issues needing careful attention to ensure the new data sources benefit society. Data protection and security need to be built-in, including “at the edge”, with clear responsibilities of what needs to be done, by whom, using which tools, and reviewed by whom.

To meet this challenge there is a need to develop harmonised standards and platforms to exploit untapped value in the mass of on-line data.

2. What is the output / impact that could be foreseen? Which innovation aspects could reach market deployment within 5-7 years?

The advent of Open Science will transform the way research is conducted and open data is a key enabler of this change. Better scrutiny of research processes will trigger faster evolution of hypotheses and methodologies. Greater sharing of the supporting IT, including both hardware and software resources, will lead to higher quality and more efficient usage of those resources. Enhanced
Ease of use will enable broader participation across scientific community and scholars from different countries, from industrial players, in particular lowering barriers to entry for SMEs, and from other users.

It is likely that all these changes will begin within 5-7 years. In particular, the exploitation of research data for other uses by entrepreneurs who see new applications can happen very quickly once the data is available. It is however very difficult to predict which data will be the source of this innovation.

To ensure that Europe is in a leading position in accelerating this innovation, the challenges described above need to be addressed through European actions targeted at removing barriers the opening up of the scientific process and the data within it.

Regarding the cultural aspects of research data there is a need for:

- Projects to support evolution and harmonisation of data policy through development white papers describing best practice to aid policy harmonization
- Actions to raise awareness of the value of data sharing and to clarify issues of data ownership and the responsibilities that go with it
- Examination of the role of publication and publishers in data related services in research
- Investigation of issues around ownership of data, costs for acquisition, maintenance and management
- New processes to support the peer review of data, to assess its contribution of value in the overall scientific progress
- Pilots to study, implement and disseminate life-cycle models that will increase efficiency
- Automation of processes to support assess the quality of the data independently of any judgement of its scientific value.
- Understanding of how to optimise public-private cooperation in the delivery of these services
- Consensus building on curricula, developing and providing education and training modules

Regarding the technical aspects of research data, specifically with respect to discoverability, there is a need for:

- Investigations into mechanisms to undertake “full data” searching, including through general purpose search engines or specialisations thereof
- Support for building of Catalogues of data by harvesting metadata from data sources, data journals
- Investigations and implementation of data mining to add value by promotion and aggregation of data sources

Regarding accessibility, intelligibility and assessability, there is a need for:
• Infrastructures for creating and maintaining unique persistent ids for all components of research, including organisations, methodologies, instruments and software as well as people, data publications. to ensure data retrieved is what is expected
• Mechanisms to assess provenance of research objects including evaluating the quality of data and metadata (Note the quality of data is not the same as the value of data)
• Projects to introduce provenanced data pipelines into research environments
• Projects to support registration of data publication events leading to collection of published data (see discovery)
• Mechanisms to address sustainability issues implied by the need for long term preservation of data

Regarding interoperability there is a need to:

• Define a semantic framework for registering of data and services that enables communication of understanding required for reuse.
• Develop an assessment and certification process, including testbeds, that demonstrates that software and services are fit for inclusion in the ecosystem of services that form the Open Science Cloud.
• Encourage incorporation of standardised software and services in advanced research communities, avoiding the risks of reinventing wheels and not invented here syndrome.
• Provide a means to link derived data to datasets from which it was generated.
• All testing must be done in collaboration but must include a strong dissemination/knowledge transfer aspect.
• Take care of the “long tail” data.

Many of these technological changes can be delivered by adoption of a service oriented architecture.

Regarding geopolitical aspects of research data there is a need to:

• Support regional and global initiatives that work on standardisation and promotion of best practice such as RDA, CODAT, W3C.

Regarding widening the sources of data and users’ base there is a need to:

• Support the bringing together IoT and Data experts to try out new ways to extract value from on-line data sources whilst adhering to the principles of responsible research and innovation.
• Undertake studies that foster the exploitation of aggregated data and method spaces by entrepreneurs in close collaboration with existing and capable infrastructures to innovative service provision.
• Need to establish standards and tools for the operationalisation of data protection by
design and to raise awareness of issues of data protection with respect to the internet of
things.
• Identify and repairing any gaps in responsibility between funders, institutions, private
sector and researchers.

In all of the above actions, it should be noted that whilst technological changes in hardware happen
on a timescale of a few years, in many fields, data and software lasts far longer and sometimes it
remains relevant in perpetuity. Long term preservation services which may be offered by
infrastructure providers should make sure that any relevant data is not lost by the transition to new
hardware and software generations. The potential for efficiency gains through sharing need to be
sought in all three, hardware, data and software.

3. Which gaps (science and technology, innovation, markets, policy) and potential game changers,
including the role of the public sector in accelerating changes, need to be taken into account?

Whilst incremental progress of scientific research is well supported through current mechanisms at
the member state and European levels, there is often a lack of appetite for truly transformational
research by comparison with other regions where more risky developments that explore new areas
and try out new methods can be funded via foundations, risk-capital etc. To stay competitive in the
long term, Europe must be willing to undertake high risk research in both public and private sectors
and avoid these activities being “outsourced” to other continents. The EC and member states must
incorporate opportunities for research with transformational potential into their funding schemes in
order to remain at the leading edge in an environment where time to market is getting ever shorter.
Support should therefore be provided for risk taking data entrepreneurs as well as larger, longer time
framed research with transformational potential.

Data needs to be seen in its whole lifecycle to support open science. From its creation, through
analysis to curation and long term preservation where appropriate and reuse, high quality data
stewardship is critical to maximising the value that can be extracted from data. This is also the case
for data from different areas of the public sector more of which should also be made available for
research. This process must be continuous and coherent if it is to support reproducibility and trigger
new research that may include reuse of the existing data.

The avalanche of data arising from new and richer data source opens many opportunities for
increasing the amount of data driven research being undertaken in both public and private sectors.
This will require a large number of data professionals, skilled in current and yet to be discovered
techniques for data analysis. For this field to be developed as quickly as possible support will be
needed for developments towards inventing and introducing new methods for data analysis and
providing education and training in these techniques.
4. Which areas could benefit from integration of horizontal aspects such as social sciences and humanities, responsible research and innovation, gender aspects, and climate and sustainable development?

The challenges and changes described above are mostly cross-disciplinary although how they should be interpreted will vary across disciplines and so they must be implemented at disciplinary level. In particular, the cultural nature of some of the changes means that analysing them from a social sciences and humanities perspective would help effect the changes as quickly and efficiently as possible.

Moreover, by linking new data to be gained under Horizon 2020 research in social sciences to existing international data repositories on societal processes (established by international programmes for research based on sample surveys), will expand considerably data on these processes.

It has been noted that the growth in data driven science will lead to a huge shortage of data professionals in the near future unless there is a very significant increase in the training of data scientists. Meeting this need can be helped by actions targeted at establishing a gender balance in this domain.

5. While staying within the limit of the RI Specific programme, how can be the new policy initiatives such as the 3O’s, the Digital Single Market (DSM) with the European Cloud Initiative, as well as the ESFRI Roadmap and the Long Term Sustainability of Research Infrastructures fully taken into account in the Work programme 2018-2020?

The actions described above are all relevant to delivering these objectives. In particular, the role of data at the centre of scientific research is directly relevant to the 3Os, DSM and the ECI. The consideration of data, and data infrastructure, as a valuable and shareable resource should be required in all new projects in the RI programme. Open data is already the default position, open science, including sharing of data-Infrastructure, software and methodologies is the next step.

References


- Expert Group reports: Riding the Wave, The Data Harvest, EOSC HLEG report, etc.

- Proposed Solutions to particular issues: Belmont Forum, Force11, RDA Recommendations, etc.
ANNEX 4 - Innovation Subgroup

Sergio Bertolucci (chair), Corinne Borel, Jean Moulin, Caterina Petrillo, Beatrix Vierkorn-Rudolph

Europe has hundreds of Research and Technical Infrastructures, covering the whole scenario of sciences and technologies and constituting a formidable repository of competences, instrumentation and skills.

In the last decades, European RIs have succeeded in establishing the paradigm of Open Science, creating an extended eco-system (at the Pan-European level, and sometimes at the global level), where the research communities are fostering a culture of mutual trust, through the balance of competition and collaboration.

On the other hand, their potential to generate innovation is largely untapped, due to the lack of a corresponding eco-system at the European scale, which needs to include also the private sector (industry, investors, entrepreneurs). The lack of such an eco-system impairs the development of policies of adequate scale, and it is one of the main causes of the declining competitiveness of Europe in innovation.

It is therefore of great importance to design a long term strategy aimed to extend the success of Open Science (in which Europe is second to nobody) to Open Innovation (one of the Commissioner Moedas 3O’s), a formidable and yet necessary task in order to connect the three pillars of H2020 (Excellent Science, Industrial Leadership and Societal Challenges) and in general to generate quality jobs and sustainable growth.

RIs, and more generally “innovation ecosystems” developed around RIs, including also Technology Infrastructures (TIs), are fundamental ingredients in order to realize this vision.

A threefold strategy for the 2018 – 2020 WP

• Deepen our understanding of Open Innovation in a Pan-European context.

The theoretical models of Open Innovation (e.g. Henry Chesbrough “Open Innovation: The New Imperative for Creating and Profiting from Technology.” HBS Press. 2003. ISBN 978-1422102831), need to be translated into the European specific environment, proposing realistic models of Open Access and IPR protection, fit to follow innovation from the early stage of Technical Readiness Level (TRL) all the way to market. This is a fundamental point for the creation of trust necessary to the establishment of a European innovation ecosystem.

• Test the model(s) with pilot initiatives.

Pilot initiatives of adequate scale in the 2018-2020 WP, addressing technologies developed in and/or for RIs, would enable to test the effective innovation potential brought about by the RIs, while casting at the same time the seeds of a European Innovation ecosystem. The development of appropriate data management tools and policies would indeed be fully covered too.
Moreover, these pilots will provide important information to the foreseen establishment of a European Innovation Council.

The examples of IMEC (including the co-innovation and co-creation models put in place), NL or Irfu Synergium of CEA should be analysed. Also the example of the “Australian National Fabrication Facility” could serve as a starting point or the German initiative “PVcomB – competence centre for thin film and nanotechnology for photovoltaics” where photovoltaic technologies and products are developed between the Helmholtz Centre Berlin and companies.

- Develop tools to quantitatively measure impact, successes and failures.

Creating tools to follow the proposed action ex ante, during the pilot phase and ex post is necessary to evaluate the model and to correct its eventual shortcomings.

The goal of these tools is to provide quantitative assessment methodologies, which are widely accepted by all the stakeholders. Such tools might then also help standardize the assessment of the individual RIs and they will in general be very useful for establishing the role of Science in the next FP. In addition, self-assessment programmes focused around innovation and based on a limited number of sufficiently ambitious Key Performance Indicators will significantly help to improve the innovation culture within RIs.

Response to the Commission questions

1. What are the challenges in the field concerned that requires action under the Work Programme 2018-2020? And would they require an integrated approach across the societal challenges and leadership in enabling and industrial technologies?

The main challenge is to demonstrate the fundamental role of RIs in the translation of the successful paradigm of Open Science into a similarly successful paradigm of Open Innovation.

This can be demonstrated through the execution of pilot projects, capable to bring together RIs with industry, entrepreneurs and private investors in a co-development effort.

Initiatives in this direction will provide a rich test bed to address many of the issues expressed in the report of the ESFRI Working Group on Innovation (March 2016), such as accessibility of RIs to industry, promotion of the innovation and industrial capabilities of the RIs, streamline of knowledge and technology transfer processes, etc. Moreover the pilots, if significant enough in terms of size, will allow testing quantitatively the combinatorial power of Open Innovation and the multiplication effect of the investment made on RIs in the creation of economical and societal value.

It would be highly desirable that the implementation of these pilots is closely coordinated among the multiple EC DGs concerned (DG RTD, DG CONNECT and DG GROWTH), in recognition of the fact that RIs are (by construction) integrating bodies across disciplines, skills and enabling technologies and they would therefore greatly benefit in term of policies and efficiency from a similar integration of the actions supported by the above mentioned EC DGs.

The pilots will be characterized by a bottom up approach on homogeneous themes, chosen on the basis of their strategic potential to connect science, industrial leadership and societal challenges.
Recommendation:

Include in the DG RTD Research Infrastructures Work Programme 2018-2020 one or more calls for the establishment of pilot initiatives of appropriate size, in collaboration with DG CONNECT and DG GROWTH, addressing the practical implementation of models enabling the translation of Open Science to Open Innovation. The number and the themes of the pilots should be determined by the participating EC DG’s, in consultation with the responsible Work Programme Committee and relevant public and private stakeholders. The scope of the pilots should focus in the streamlined integration of the various actors and the test of sustainable models enabling the exploitation of the whole value chain from fundamental science to the market. The calls should rely on clear and tangible performance indicators for the pilots.

2. What is the output/impact that could be foreseen? Which innovation aspects could reach market deployment within 5-7 years?

The foreseen impact of these pilots within 5 to 7 years will be very significant:

Technology
- Development of new high performance materials, devices and systems.
- Streamline the transition of breakthrough technologies towards the market related to paradigms like the Internet of Things, Health Care, Intelligent Transport, Sustainable Energy and Resources, Big Data (network, data mining and processing, meta data analysis...), etc.

Industry
- New opportunities for cutting-edge manufacturing and production processes in high added value European industrial sectors such as nanotechnology, magnets, semiconductors, aeronautics, health care, etc. through early involvement of industry in the design and manufacturing of components and instruments.
- A new competitive edge for European firms.

Business
- New opportunities for young entrepreneurs, especially in the high tech and data management areas.
- Opportunities for (micro) SMEs to consolidate and grow.

Strategy and policy
- Measurable models that will leverage the investments made in RIs as well as provide sustainable operational perspectives for the mid and long term future.
3. **Which gaps (science and technology, innovation, markets, policy) and potential game changers, including the role of the public sector in accelerating changes, need to be taken into account?**

As commented before the rationale underlying the running of the proposed pilots is to gather evidence that it is possible to bridge the gap from Open Science to Open Innovation and that the RIs, with their history of successfully implementing Open Science, can become the enablers of Open Innovation in the European Research Area.

The pilots will have to face many difficult issues, but they will certainly represent a serious attempt to implement future innovation policies based on evidence, as it is much desired by policy makers and ultimately by EU citizens.

The role of public funding in accelerating changes is vital: public funding is the principal agent (if not the only one) truly capable of absorbing early stage risks associated to breakthrough technologies and forward-looking initiatives, creating in this way a path for the ingress of private investments. The role of private investments is then to generate the multiplication factor of public investment.

4. **Which areas could benefit from integration of horizontal aspects such as social sciences and humanities, responsible research and innovation, gender aspects, and climate and sustainable development?**

The proposed pilots will include RIs from all scientific areas, business, innovation, social science and data specialists, not only in order to facilitate the transition from an idea to the market and to provide tools and guidance to young entrepreneurs, but also to perform a continuing in-depth assessment of the progress and of the trends of the pilots.

It is pretty likely that the study of the pilots might result into significant theoretical contribution to the evolution of the Open Innovation paradigm.

5. **While staying within the limit of the RI Specific programme, how can be the new policy initiatives such as the 3O’s, the Digital Single Market (DSM) with the European Cloud Initiative, as well as the ESFRI Roadmap and the Long Term Sustainability of Research Infrastructures fully taken into account in the Work programme 2018-2020?**

The 3O’s, the Digital Single Market (DSM) and the European Cloud Initiative are characterized by the paradigm of openness and therefore the strategy outlined above will be fully synergetic, greatly contributing to the goal of creating a European Innovation Area.

Balancing top down and bottom up approaches will certainly speed up the process of creation of trust and of a shared innovation culture, which are necessary ingredients for the establishment of an innovation ecosystem.

This is fully in line with the strategy developed by ESFRI and it will constitute a founding pillar for the Long Term Sustainability of RIs.
Long-term sustainability of RIs can only be ensured if Europe continues to develop cutting-edge technologies and has industrial companies able to build them. The increasing size and cost of RIs imply large fluctuations in time for the construction and operation phases, which can dissuade industrial companies. The sharing of information, pooling of resources, coordination of R&D activities, and access to fabrication, assembly and verification platforms is therefore essential and should continue to be funded mainly by public investment in-between large-scale project construction.
## ANNEX 5 - List of the EAG H2020 RI members

<table>
<thead>
<tr>
<th>Given name</th>
<th>Family name</th>
<th>Gender</th>
<th>Position</th>
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<tbody>
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<td>Holmgren</td>
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<td>Kotowska</td>
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<td>Macek</td>
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<td>Moulin</td>
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<tr>
<td>Peter</td>
<td>Wittenburg</td>
<td>M</td>
<td>Senior Advisor at the Max Planck Institute for Psycholinguistics (after retirement from Technical Directorship)</td>
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