



Open Innovation Open Science Open to the World

– a vision for Europe



Research and
Innovation

EUROPEAN COMMISSION

Directorate-General for Research and Innovation
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Open **Innovation**
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– a vision for Europe

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FOREWORD

Most of the political priorities set for my mandate as President of the European Commission depend to a greater or lesser extent on research and innovation.

Research and innovation create investment opportunities for new and better products and services and therefore increase competitiveness and employment. This is why the Investment Plan for Europe through the European Fund for Strategic Investments is investing so heavily in innovation related projects and SMEs, over thirty billion euro to date. I am also proud that the European Union is increasing its financial commitment to research and innovation funding through the Horizon 2020 programme and the European Structural and Investment Funds.

Research and innovation is a key component of thematic policies. It is central to the Digital Single Market, both to enable industry to benefit from digital technologies and to underpin scientific advance through the development of a European Science Cloud. It is equally self-evident that Europe's ambitions on energy and on climate change will depend, ultimately, on the development and deployment of new, clean technologies.

Research and innovation can also contribute to the European Union as a stronger Global Actor, as other parts of the world seek to work with our leading scientists and because scientific relations can flourish even where international relations are strained.

Science more generally has a critical role across many areas of policy in providing evidence that helps understand the risks and benefits of different policy choices. This is why I tasked Commissioner Moedas to develop the Scientific Advice Mechanism to strengthen the independence of scientific advice

across the Commission and improve interactions between science and policy.

This publication shows how research and innovation is changing rapidly. Digital technologies are making the conduct of science and innovation more collaborative, more international and more open to citizens. Europe must embrace these changes and reinforce its position as the leading continent for science, for new ideas, and for investing sustainably in the future.

A handwritten signature in blue ink, consisting of a stylized 'J' followed by a long horizontal line that tapers off to the right.

Jean-Claude Juncker,
President of the European Commission.



INTRODUCTION

When I took office as European Commissioner for research, science and innovation, it was important to me to listen to and learn from Europe's research, science and innovation communities. There are many things that Europe does extremely well, such as the European Research Council which, in a few short years, has put in place a unique way of supporting the very best science in Europe. However, it also became apparent to me that the way that science works is fundamentally changing and an equally important transformation is taking place in how companies and societies innovate. Put simply, the advent of digital technologies is making science and innovation more open, collaborative, and global.

These exchanges led me to set three goals for EU research and innovation policy, which I have

summarised as Open Innovation, Open Science and Open to the World. These goals, first set out in a speech I gave in June 2015, show how research and innovation contribute across the European Commission's political priorities. They do not represent a new policy initiative or funding programme as such, but a way to reinforce existing programmes, such as Horizon 2020, and reinvigorate existing policies such as the European Research Area.

This book brings together some of the key conceptual insights behind Open Innovation, Open Science and Open to the World and highlights actions that are already taking place or are being prepared. For example, the Open Innovation goal has led to a debate on a possible European Innovation Council and the creation of a Seal of Excellence to facilitate links between Horizon 2020 and other funding programmes. The Open Science goal is materialising in the development of a European Science Cloud and greater openness to scientific data generated by Horizon 2020 projects. The Commission has already taken historic steps to be Open to the World by signing Association Agreements with Ukraine and Tunisia to Horizon 2020, as well as international agreements with China and South American countries.

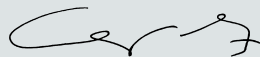
As set out in the chapter on Open Innovation, Europe is excelling at many things, but we are not good enough at investing in innovation at speed and scale. This is why Open Innovation is the first goal. Europe has great diversity and is well placed to succeed in the next wave of innovation that will be found at the interfaces between digital, physical and biological technologies, between the arts, business and science, and between data, users and organisations. Innovators do not need help from the EU to come up with great ideas, but the level of success their ideas can ultimately reach is certainly influenced by regulation, financing, public support and market access. The EU is playing a crucial role in improving all these success factors.

Europe is the world's largest producer of knowledge, but the phenomenon described in the chapter on Open Science is changing every aspect of the scientific method to become more open, inclusive and interdisciplinary. If scientists want to monitor the effects of climate change on local ecosystems, for example, they can now use citizen reporting or data from smartphones. Ensuring Europe is at the forefront of Open Science means promoting open access to scientific data and publications alongside the highest standards of research integrity.

There are few forces in this world as engaging and unifying as science. The universal language of science maintains open channels of communication where other foreign policy approaches are not viable. The chapter 'Open to the World' sets out the gains the EU can make by maintaining its presence at the highest level of international scientific endeavour and through promoting our competitive edge in global knowledge markets in the information age.

I hope that the ideas and initiatives described in this book will stimulate anyone interested in European research and innovation. I would like it to encourage debate and lead to new ideas on what the European Union should do, should not do, or do differently.

This book would not have been possible without the dedication and knowledge of the staff in the Directorate-General for Research and Innovation in the European Commission and I would like to thank everyone who contributed with their hard work, discussions and enthusiasm.



Carlos Moedas,
Commissioner for Research,
Science and Innovation.

The image features a minimalist design on a light gray gradient background. In the lower-left and center, there are three overlapping circles. One circle is a medium gray, another is a darker charcoal gray, and the third is a vibrant orange. The orange circle is the largest and is positioned on the right side of the cluster. The text "Open Innovation" is written in white, with "Open" on the top line and "Innovation" on the bottom line, both in a clean, sans-serif font. The text is placed within the orange circle, slightly to the right of the center.

Open
Innovation

OPEN INNOVATION

The European Union is a research powerhouse, still the world's leading producer of scientific knowledge, ahead of the United States. However, Europe too rarely succeeds in turning research into innovation, in getting research results to market. Too often, new technologies that have been developed in Europe are commercialised elsewhere.

Europe must get better at making the most of its innovation talent, and that's where Open Innovation comes into play. This chapter describes the initiatives that the Commission is taking and will take to create an Open Innovation ecosystem where innovation can flourish.

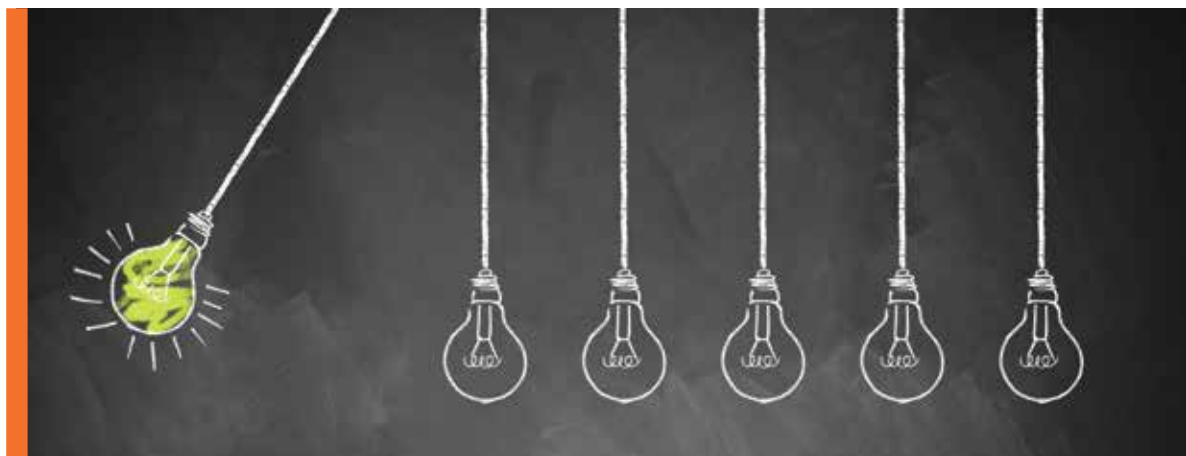
But, first, what is meant by Open Innovation? The basic premise of Open Innovation is to open up the innovation process to all active players so that knowledge can circulate more freely and be transformed into products and services that create new markets, fostering a stronger culture of entrepreneurship.

Open Innovation was defined by Henry Chesbrough¹ as the *"use of purposive inflows and outflows of*

knowledge to accelerate internal innovation". This original notion of Open Innovation was largely based on transferring knowledge, expertise and even resources from one company or research institution to another. This assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they seek to improve their performance (see Figure OI.1).

The concept of Open Innovation is constantly evolving and is moving from linear, bilateral transactions and collaborations towards dynamic, networked, multi-collaborative innovation ecosystems; a trend that was recognised by an Independent Expert Group on Knowledge Transfer and Open Innovation, set up by DG Research and Innovation in 2012 (see Figure OI.2 on Open Innovation mechanisms).

This means that a specific innovation can no longer be seen as the result of predefined and isolated innovation activities but rather as the outcome of a complex co-creation process involving knowledge flows across the entire economic and social environment.



¹ Chesbrough, Henry (2006) <http://openinnovation.net/Book/NewParadigm/Chapters/index.html>; "Open Innovation: A New Paradigm for Understanding Industrial Innovation," in Henry Chesbrough, Wim Vanhaverbeke, and Joel West, eds. <http://hchesbrough.wpengine.com/NewParadigm> "Open Innovation: Researching a New Paradigm. Oxford: Oxford University Press

Figure 01.1: Contrasting Principles of Closed and Open Innovation

CLOSED INNOVATION PRINCIPLES	OPEN INNOVATION PRINCIPLES
The smart people in our field work for us.	Not all the smart people work for us. We need to work with smart people inside and outside our company.
To profit from R&D, we must discover it, develop it, and ship it ourselves.	External R&D can create significant value; internal R&D is needed to claim some portion of that value.
If we discover it ourselves, we will get it to market first.	We don't have to originate the research to profit from it.
The company that gets an innovation to market first will win.	Building a better business model is better than getting to market first.
If we create the most and the best ideas in the industry, we will win.	If we make the best use of internal and external ideas, we will win.
We should control our IP, so that our competitors don't profit from our ideas.	We should profit from others' use of our IP, and we should buy others' IP whenever it advances our own business model.

Source: Table I-1 from *Open Innovation: The New Imperative for Creating and Profiting from Technology* by Henry Chesbrough (Harvard Business Review Press, 2005)

This co-creation takes place in different parts of the innovation ecosystem and requires knowledge exchange and absorptive capacities from all the actors involved, whether businesses, academia, financial institutions, public authorities or citizens.

Figure 01.2: Open Innovation mechanisms



Source: DG Research and Innovation, Knowledge Transfer and Open Innovation Study (on-going)

1. OPEN INNOVATION – THE CONCEPT IN EVOLUTION

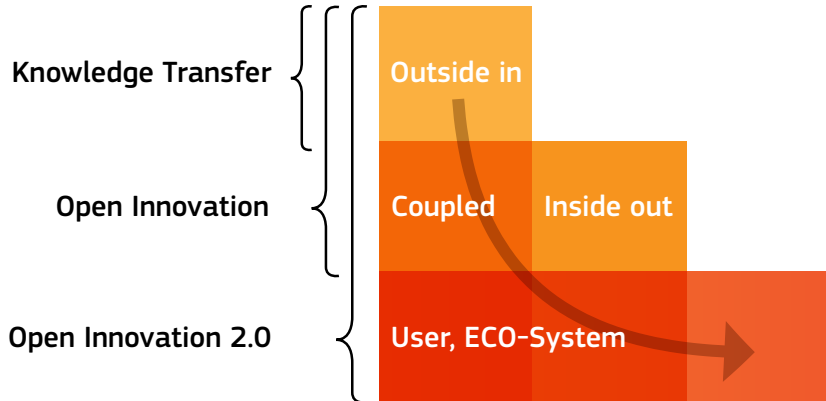
Open Innovation is a broad term, which encompasses several different nuances and approaches. Two main elements underpin the most recent conceptions of Open Innovation, for which academics have coined the term Open Innovation 2.0²:

1. **the users** are in the spotlight: an invention becomes an innovation only if users become a part of the value creation process (see Figure 01.3). Notions such as ‘user innovation’, as coined by Eric von Hippel³, emphasize the role of citizens and users in the innovation processes as ‘distributed’ sources of knowledge. This kind of public engagement is one of the aims of the Responsible Research and Innovation⁴ programme in Horizon 2020. The term ‘open’ in these contexts have also been used as a synonym for ‘user-centric’;⁵

2. **creating a well-functioning eco-system** that allows co-creation becomes essential for Open Innovation. In this eco-system relevant stakeholders are collaborating along and across industry and sector-specific value chains to co-create solutions to socio-economic and business challenges. This co-creation process should join forces at the EU, Member State and regional level.⁶

One important element to keep in mind when discussing Open Innovation is that it cannot be defined in absolutely precise terms. It may be better to think of it as a point on a continuum: there is a range of context-dependent innovation activities at different stages, from research, to development through to commercialisation, where some activities are more open than others⁷.

Figure 01.3: From Knowledge Transfer to Open Innovation 2.0



Source: DG Research and Innovation, Knowledge Transfer and Open Innovation Study (on-going)

² Independent Expert Group Report on Open Innovation & Knowledge Transfer, Directorate-General for Research and Innovation, 2014; Cf. also Open Innovation Strategy and Policy Group (OISPG).

³ Cf e.g. E. von Hippel, “Democratizing Innovation”, Cambridge, MA: MIT Press, 2005.

⁴ https://ec.europa.eu/research/swafs/pdf/pub_public_engagement/responsible-research-and-innovation-leaflet_en.pdf

⁵ H. Chesbrough and M. Bogers, “Explicating Open Innovation: Clarifying an Emerging Paradigm for Understanding Innovation”, in Henry Chesbrough, Wim Vanhaverbeke and Joel West, eds. New Frontiers in Open Innovation, Oxford University Press, 2014

⁶ Independent Expert Group Report on Open Innovation & Knowledge Transfer, Directorate-General for Research and Innovation, 2014

⁷ L. Dahlander and D. Gann, “How open is innovation?”, Research Policy 39, 2010

- combining the power of ideas and knowledge from different actors (whether private, public or civil society/third sector) to co-create new products and find solutions to societal needs;
- creating shared economic and social value, including a citizen and user-centric approach;
- capitalising on the implications of trends such as digitalisation, mass participation and collaboration.

The practical steps that the Commission will take to create a European Open Innovation ecosystem are grouped in three broad areas or pillars, described below in the section *Open Innovation in the New Commission Priorities*.



Open Innovation Platforms

There are many examples of successful Open Innovation platforms in Europe, with different models for supporting Open Innovation either in more conceptual or more practical ways. The following are just two among many such examples.

The Demola platform (www.demola.net) is an international organization that facilitates co-creation projects between university students, companies and researchers, both locally and internationally. Demola is a co-creation concept that is geared to solving real challenges. Every project has an outcome – be it a new concept, a demo, or a prototype. If the partner company finds the outcome useful, the company can license or purchase the outcome, and take it for further development. Each partner has a clear role, and the work is guided by simple procedures. Contracts, intellectual property rights, licensing models, and other legal requirements are in place and meet international business standards and practices.

High Tech Campus Eindhoven (www.hightechcampus.com) in the Netherlands brings together more than 140 companies, startups and institutes. Some 10,000 researchers, developers and entrepreneurs are working on developing future technologies and products that will affect the lives of billions of people. The ecosystem of open innovation helps Campus-based companies to accelerate innovation, by offering easy access to high tech facilities and international networks.

Campus companies (including Philips, NXP, IBM and Intel) strategically decide what knowledge, skills and R&D facilities they share in order to achieve faster, better and more customer-oriented innovation in the fields of health, energy and smart environments. High Tech Campus Eindhoven reports that Campus companies are responsible for nearly 40% of all Dutch patent applications.

2. THE LINK TO OPEN SCIENCE AND OPEN TO THE WORLD

In order to encourage the transition from linear knowledge transfer towards more dynamic knowledge circulation, experts⁸ agree that it is essential to create and support an (open) innovation ecosystem that facilitates the translation of knowledge into socio-economic value.

In addition to the formal supply side elements such as research skills, excellent science, funding and Intellectual Property management, there is also a need to concentrate on the demand side aspects of knowledge circulation, making sure that scientific work corresponds to the needs of the users and that knowledge is findable, accessible, interpretable and re-usable (FAIR).

Open Access to research results, an essential part of Open Science, which aims to make science more reliable, efficient and responsive, is therefore the springboard for increased innovation opportunities, for instance by enabling more science-based start-ups to emerge.

As noted by Chesbrough⁹, prioritising Open Science does not, however, automatically ensure that research results and scientific knowledge are commercialised or transformed into socio-economic value. In order for this to happen, Open Innovation must help to connect and exploit the results of Open Science and facilitate the faster translation of discoveries into societal use and economic value.

⁸ Independent Expert Group Report on Open Innovation & Knowledge Transfer, Directorate-General for Research and Innovation, 2014

⁹ H. Chesbrough, From Open Science to Open Innovation, Science|Business Publishing 2015, <http://www.sciencebusiness.net/eventsarchive/OpenScience/>

Collaborations with international partners represent important sources of knowledge circulation. The globalisation of research and innovation is not a new phenomenon but it has intensified in the last decade, particularly in terms of collaborative research, international technology production and worldwide mobility of researchers and innovative entrepreneurs.

International collaboration plays a significant role both in improving the competitiveness of Open Innovation ecosystems and in fostering new knowledge production worldwide. It ensures access to a broader set of competences, resources and skills wherever they are located, and it yields positive impacts in terms of scientific quality and research results. It enables global standard-setting, allows global challenges to be tackled more effectively, and facilitates participation in global value chains and new and emerging markets.

An example of Open Innovation in automated transport

Today, a number of prototype automated vehicles and transport systems exist in various stages of development.

In terms of transportation systems, the automated ones currently in operation function within the comfortable confines of dedicated, protected infrastructure. The CityMobil2 project funded by the 7th Framework Programme seeks to take this to the next level, with automated transport systems using the existing road infrastructure. Systems like this can provide transport on demand for areas with low demand for conventional transportation.

The four-year project aims to demonstrate that automated systems are viable transport options for outlying urban areas and small towns. With 45 partners drawn from system suppliers, public authorities, the research community and networking organisations, CityMobil2 has procured the technology required to demonstrate that automated transportation is feasible. This includes the EasyMile EZ-10, a self-driving electric car which is not only ideal for the transportation of passengers, but can also be adapted for logistical and freight use. Partly thanks to the project two companies created the EasyMile joint venture which produced the first automated road transport vehicle on an industrial scale.

CityMobil2 is also studying the long-term socio-economic, environmental, cultural and behavioural ramifications of automated transportation. The resulting analyses of these and the technical aspects of the project will be used to plot possible future courses and define different possible scenarios for automated transport.

3. OPEN INNOVATION IN THE NEW COMMISSION PRIORITIES

How can the concept of Open Innovation be translated into efficient and effective policies? As stated in the political priorities of Commissioner Moedas¹⁰, creating and supporting an Open Innovation ecosystem encourages dynamic knowledge circulation and facilitates the translation of that knowledge into socio-economic value.

**The ecosystem underpinning
Open Innovation: the importance of
creating the right framework conditions**

Figure OI.4 shows how the main elements of the innovation ecosystem contribute to fostering Open Innovation. The public sector, the financial sector, innovative businesses, academia and citizens all have an essential part to play in delivering on the three pillars of the European Commission's approach to Open Innovation.

Figure OI.4: The roles of the different actors in Open Innovation

THE PUBLIC SECTOR

The public sector has a central role to play in promoting Open Innovation. First and foremost it creates the regulatory environment in which all other actors operate. It puts in place rules and tools that can incentivise an open circulation of knowledge and cooperation among different actors with the aim to develop and market innovative solutions. Secondly, it offers better modes of coordination among the economic actors involved in order to enhance productivity and value. Thirdly, it can create a demand for innovation, both through the above-mentioned regulatory means and, for instance, through the procurement of innovative solutions.

THE FINANCIAL SECTOR

Innovation can be a risky business, therefore accessing funding and / or finance is not always easy for those who have innovative ideas. Building more innovation-friendly financial instruments and institutions and promoting the integration of existing funds and tools is essential to support Open Innovation. It is important that investors of all kinds find their interest in investing in innovation.

INNOVATIVE BUSINESSES

Businesses play a key role in innovating. In order to be able to bring innovations to the market, they must be able to maximise their returns on the resources allocated to innovating. This is the reason why it is important to reduce European market fragmentation, while fostering faster market access and development.

ACADEMIA

Universities, Higher Education Institutions, and Public Research Organisations / Research and Technology Organisations have a key role to play in the innovation eco-system, not only as knowledge producers, but also as co-creators and generators of skilled human capital. Challenges in this component of the eco-system include the co-creation capabilities of universities, the design of incentives for academics when working with users and the absorptive capacity of academic knowledge within firms.

CITIZENS

Citizens, users and Civil Society Organisations have a central and transversal role to play in bringing innovation to the market. They create a demand for innovative products and services, they can fund and / or finance projects that are relevant to them, they can be at the source of innovative ideas worth spreading and scaling up and they can have a say in what research is meaningful to them and can impact their lives.

¹⁰ http://europa.eu/rapid/press-release_SPEECH-15-5243_en.htm

The Commission aims to ensure that the appropriate framework conditions for innovation are in place through the three pillars of its Open Innovation policy. These are: Reforming the Regulatory Environment, Boosting Private Investment and Maximising Impacts.

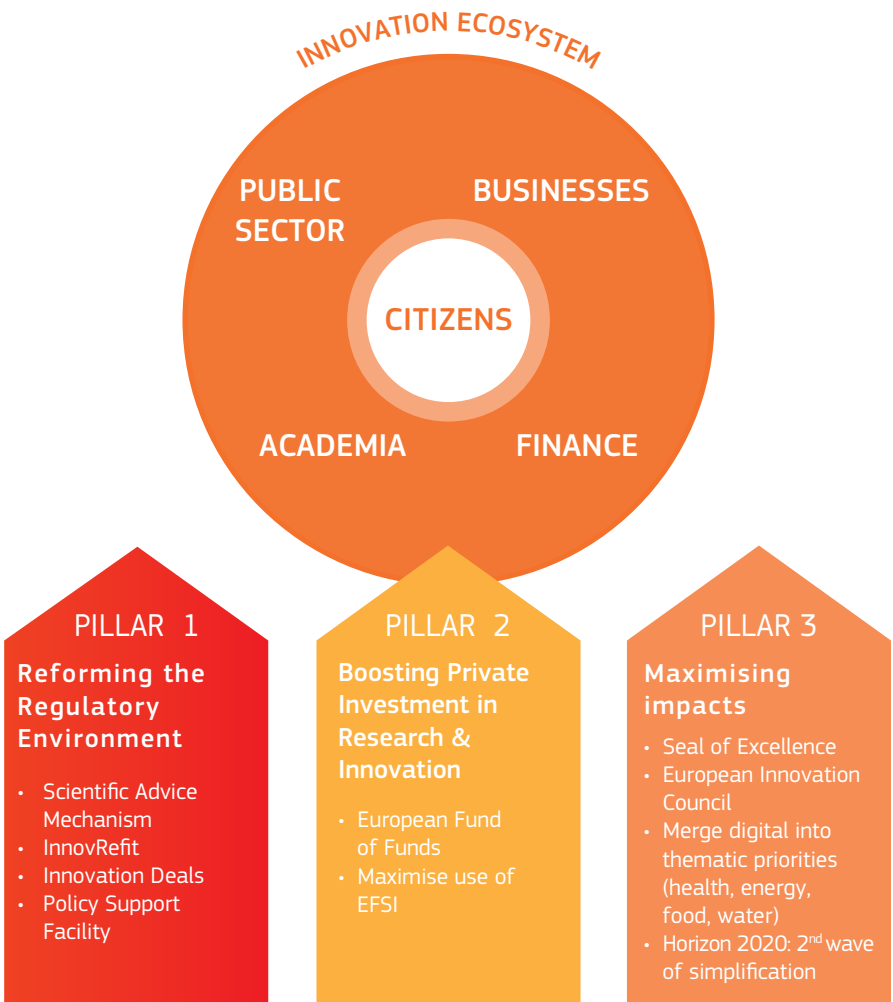
First, Europe needs to create the right regulatory environment that removes obstacles to innovation and encourages innovators and entrepreneurs, while rule and standard-setting must keep up with rapidly changing technologies. Fewer regulatory barriers will help encourage more investment in innovation, but much more needs to be done. This brings us to the second pillar: comparing the levels of investment

in the EU and the US, it's clear that the European innovation ecosystem is lacking adequate private financial instruments (with far less venture capital in Europe, and venture capital funds do not have the scale or scope to grow companies).

Under the third pillar, the Commission will strive to get the most out of EU-level support for innovation by developing new actions to get more innovation impact out of Horizon 2020, including through better synergies with the Structural Funds.

The three pillars, and examples of specific actions under each one, are synthesised in Figure 01.5 and discussed in more detail below.

Figure 01.5: The Commission's three pillars of action



PILLAR 1

REFORMING THE REGULATORY ENVIRONMENT

“We need to tear down the regulatory barriers that hamper innovation. We need a better regulatory environment that creates an appetite among private investors to invest in Europe. That’s no easy feat – legislative processes can take several years to adapt to new technologies that are evolving every month. That’s why I have made smart regulation part of my priority Open Innovation, and why I appreciate that the Dutch Presidency has put this high on the list of its own priorities for research and innovation.”

*Commissioner Carlos Moedas,
Informal Competitiveness Council, Amsterdam, 27 January 2016*

The pillar on Reforming the Regulatory Environment is about ensuring that regulations are not an obstacle to innovation and that, whenever possible, they support it. To achieve this, it is essential to identify the ways in which regulation affects all elements of the eco-system and their interactions. The following sections describe initiatives that the Commission is developing or exploring to help reform and improve the regulatory environment in favour of innovation.

Scientific Advice Mechanism

Scientific evidence is at the very heart of the Commission’s goal of better regulation. It is for this reason that the Commission has created the Scientific Advice Mechanism (SAM) to provide high quality, timely and independent scientific advice for its policy-making activities. This will help improve the quality of EU legislation, in line with the Better Regulation agenda. The creation of a better regulatory environment is an essential component of the Commission’s Open Innovation agenda, to which SAM will make a vital contribution.

SAM is a system that brings together evidence and insight from different disciplines and approaches, taking into consideration the specificities of EU policy making, and ensuring transparency. It will complement the work of the Joint Research Centre,

the Commission’s in-house scientific service, and of existing specialist committees.

SAM will have a structured relationship with scientific advisory bodies, within the Member States and more widely. In particular, there will be close interaction with the European scientific academies, who will play a key role in providing the best scientific evidence needed for the EU policy-making process.

Following President Juncker’s declaration in May 2015 to set up a new scientific advice structure, Commissioner Moedas and the Directorate-General for Research and Innovation established SAM as quickly as possible.

The core of SAM is the High Level Group of seven Scientific Advisors. They were appointed in November 2015 following an open call for nominations and the recommendations of an independent identification committee. The first meeting of the High Level Group took place in January 2016.

The Commission is committed to ensuring SAM’s success, and committed to establishing closer links between science and policy-making. The ultimate aim is to deliver better, evidence-based policies for Europe that will contribute to solving global challenges in a consensual way.

The seven members of the first SAM High Level Group

Janusz M. Bujnicki	Professor, Head of the Laboratory of Bioinformatics and Protein Engineering, International Institute of Molecular and Cell Biology, Warsaw
Pearl Dykstra	Professor of Sociology, Erasmus University, Rotterdam
Elvira Fortunato	Professor, Materials Science Department of the Faculty of Science and Technology, NOVA University, Lisbon
Rolf-Dieter Heuer	President of the Deutsche Physikalische Gesellschaft
Julia Slingo	Chief Scientist, Met Office, Exeter
Cédric Villani	Director, Henri Poincaré Institute, Paris
Henrik C. Wegener	Executive Vice-President, Chief Academic Officer and Provost, Technical University of Denmark

Source: <https://ec.europa.eu/research/sam/index.cfm>

InnovRefit

Europe is lagging behind major competitors in the levels of private investment in R&D. More appropriate framework conditions could both maximise the impact of public spending

and increase the incentives for private sector investment. Getting the regulatory framework right is crucially important to getting innovative products and services to market and to allowing innovators to benefit from the scale and scope of the Single Market.

Health technology assessment for pharmaceuticals – an example of better regulation for health

The price and reimbursement of medicines is largely defined by the health technology assessment (HTA) process, performed by independent agencies that analyse the medical, economic, social and ethical implications of the value, effectiveness, costs and impact of a health intervention. With some 50 national or regional HTA agencies in Europe carrying out assessments individually, fragmentation is high. Due to the limited standardisation and coordination of HTA in Europe, healthcare manufacturers need to address multiple stakeholders and systems with varying requirements, in order for patients to access their products in the different national markets. The varying HTA results between countries also raise the question of objectivity and accuracy of assessments, which are necessary to reward developers for true innovation. The Commission has launched initiatives aimed at improving cooperation between HTA agencies at European level. Their results will serve as a basis for possible decisions regarding pathways to an improved coordination and mutualisation of the work of national or regional HTA agencies, thereby potentially facilitating pharmaceutical innovation in the EU.

In December 2015 the Commission published its report *Better regulations for innovation-driven investments at EU level*¹¹. This document presented, for the first time, an in-depth analysis of how the regulatory environment at EU level can hamper, or stimulate, innovation. It was developed following consultations with Member States and a range of organisations and industry stakeholders. The information gathered and its analysis by the Commission provide an evidence base of case

studies across different sectors and a springboard to discussion and action at political level.

The Commission, together with the rotating Presidencies of the Council, will continue to develop this preliminary analysis and collect further suggestions on the relationship between innovation and regulation, indications of regulatory barriers to innovation and suggestions for simpler, clearer and more efficient regulation that supports growth and jobs.

“We need to work to improve the framework conditions for innovation. Therefore, we are investigating how to combine the large scale demonstration projects with regulatory innovation. For example, building on experiences in some Member States, we could envisage allocating a space within large-scale demonstration projects to stress-test regulatory frameworks in a practical manner.

The ‘regulatory innovation space’ would only apply to the demonstration or testing phase, not to the further roll-out of solutions, but it would clarify where the regulatory framework may require evolution in order to promote workable solutions. Investing in work programmes, removing barriers – these are essential steps, but they are only the tip of the iceberg. The Commission is doing a lot more and I’m glad to have you with us on this journey.”

Commissioner Carlos Moedas,
“Key challenges for the water sector”, European Parliament, Brussels, 20 April 2015

Innovation Deals

Timing is crucial for innovation. Existing regulations may not be able to keep up with rapid technological and systemic change and ever-quicker timescales for developing and introducing innovations. Innovators may find themselves hindered in bringing new and promising solutions to market. Innovations with valuable socio-economic or environmental potential may be delayed or impeded.

In order to avoid such unintended consequences of EU regulation, the Commission is exploring the idea of making it possible for innovators to question EU rules that are identified as posing obstacles to innovation. This would be done jointly

with the competent EU, and possibly also national, authorities through ‘Innovation Deals’, which would be a new way of addressing EU regulatory obstacles to innovation in a pragmatic, open and transparent way.

Innovation Deals would be a form of voluntary cooperation between innovators, national, regional and local authorities and the Commission. The idea is to bring together innovators and regulators so that they reach a common understanding of how a specific innovation can be introduced within existing regulatory frameworks. The Deals in themselves would be an innovation in how the Commission works, helping form a more modern and responsive administration, in line with the Commission’s Better Regulation Agenda¹².

¹¹ http://ec.europa.eu/research/innovation-union/pdf/innovrefit_staff_working_document.pdf#view=fit&pagemode=none

¹² http://ec.europa.eu/smart-regulation/index_en.htm

Innovation Deals would be available for innovations that are recently on the market or have only limited or no market access. They should not contravene or derogate from existing EU legislation, but clarify possible “grey zones” or may make use of the flexibility permitted by different types of legislation, eventually leading to the testing or application of the innovative solutions without infringing or jeopardising any fundamental environmental, social or competition principles.

The Commission is launching a first pilot of the Innovation Deals in the area of the Circular Economy. An open invitation will ask innovators to identify where they think EU regulatory frameworks are blocking their innovations. The innovations addressed will need to be genuinely new and meet or surpass the overall objectives of the legislation fully. For example, they could be innovative ways to recover

resources from waste water, or the use of new technologies to achieve waste recycling targets. The Commission will select the innovations that are most relevant at EU level: working with the innovator and national authorities to improve legislative clarity; or to identify and apply existing flexibility, while fully complying with legislative requirements.

The outcome of an Innovation Deal would be a clarification of how the EU rule or legislation applies, together with better guidance on its intention, through a better cooperation between innovators and institutions in order to demonstrate how the solution could be implemented. If the existence of a regulatory obstacle is confirmed as a barrier to an innovation that could bring wider benefits, the European Commission services may consider beginning the process to amend the relevant legislation.

AMCARE – An example of Open Innovation in health

*The **AMCARE** project, funded by the 7th framework Programme for Research, represents a major interdisciplinary effort between stem cell biologists, experts in advanced drug delivery, research scientists, clinicians and research companies working together to develop new ways to address the challenges of treating acute heart disease. The researchers will use adult stem cell therapy with smart biomaterials and advanced drug delivery and combine such treatments with minimally-invasive surgical devices. The project represents a multi-stakeholder approach and is truly co-creative in the spirit of Open Innovation. It facilitates the translation of research knowledge into something of genuine socio-economic value and may represent a significant evolution in cardiac treatment. The Open Innovation seen in the project has already been so successful that a number of the existing partners have since begun another project to revolutionise the treatment of other diseases.*

Horizon 2020 Policy Support Facility

The Horizon 2020 Policy Support Facility (PSF) was established in March 2015 to offer Member States and countries associated to Horizon 2020 practical support to design, implement and evaluate policy

reforms that enhance the quality of their research and innovation investments and national systems. Such reforms concern, for example, the stimulation of stronger and closer links between science and business or the introduction of performance-based funding of public research institutes.

“Sometimes a fresh look, a different perspective, is what you need to get the most out of your national system... The Policy Support Facility is voluntary and provides a broad range of services. What sets the PSF apart is that we listen to what Member States want. What has been delivered is tailor-made advice that purely acts on the requests of the Member States. Timing, political commitment, scope and many more elements are adjusted according to national needs.”

Commissioner Carlos Moedas, Promoting research and innovation reforms through the Policy Support Facility, Sofia, 8 October 2015

The Horizon 2020 PSF is a demand-driven service that responds to requests from national authorities on a voluntary basis. It provides independent high-level expertise and analyses through a broad range of services such as peer reviews of national research and innovation systems, support for specific reforms and project-based mutual learning exercises. In addition, the PSF provides a Knowledge Centre with a website¹³ with comprehensive information and analysis on research and innovation performance and policy responses in each Member State.

Three pilot PSF activities were launched in 2015: a peer review of the Bulgarian research and innovation system¹⁴, a pre-peer review of the Hungarian research and innovation system¹⁵ and a mutual learning exercise on policies to foster business research and innovation investments. A number of new activities have been foreseen for 2016.

The Horizon 2020 Policy Support Facility supports smart policy reforms including ones to improve the regulatory environment to make it more innovation-friendly; to stimulate business engagement with and investments in research and innovation; and to maximise the impact of research and innovation investments.

PILLAR 2

BOOSTING PRIVATE INVESTMENT IN RESEARCH AND INNOVATION

This pillar is about ensuring access to finance for innovative ideas, creating better conditions for the private sector to invest in innovation activities and bringing together investors throughout Europe to better exploit the potential of the Single Market to finance innovation. The following section discusses the policy measures to be taken by the Commission.

The European Venture Capital Fund of Funds

Venture capital (VC) supports businesses as they start up and grow. VC is particularly important for innovative companies in sectors such as life sciences, clean technology and ICT. Firms with VC backing are more likely to bring innovations to market, generate patents and other forms of intellectual property, show higher productivity, grow faster, and become more competitive than their peers without venture capital.

However, VC in Europe is over-dependent on funding from public sources, which account for over 30% of total fund-raising. Large institutional investors mention two main reasons for their reluctance to invest more substantial amounts in European VC: European VC funds are usually too small to accept the large sums these investors want to invest, and returns on investments are inadequate.

¹³ <https://rio.jrc.ec.europa.eu/>

¹⁴ <https://rio.jrc.ec.europa.eu/en/library/horizon-2020-policy-support-facility-peer-review-bulgarian-research-and-innovation-system>

¹⁵ <https://rio.jrc.ec.europa.eu/en/library/horizon-2020-policy-support-facility-pre-peer-review-hungarian-research-and-innovation>



A pan-European VC Fund-of-Funds (FoF) could help overcome these obstacles. If large enough, it could accept large private-sector investments, and could also offer a better rate of return by diversifying the range of VC funds into which these investments are channelled.

This is why the European Commission is currently considering how best to set up one or more VC Fund-of-Funds. Such a Fund-of-Funds would be managed by a high-level manager selected through an open and competitive call for expression of interest.

Maximising the use of the European Fund for Strategic Investments (EFSI)

The European Fund for Strategic Investments (EFSI)¹⁶ aims to overcome the current investment gap in the EU by mobilising private funding both for strategic investments in infrastructure and innovation and also for risk finance for small businesses. The European Commission expects EFSI to mobilise at least EUR 315 billion in additional investments in Europe by 2018.

EFSI has two parts: an Infrastructure / Innovation Window aiming for EUR 240 billion of investments, implemented by the EIB; and an SME Window aiming for EUR 75 billion of investments, implemented by the European Investment Fund (EIF).

Research, development and innovation (RDI) is one of the priority sectors targeted by EFSI, and Horizon 2020 has contributed to the financing of the EU guarantee through a redeployment of EUR 2.2 billion from its budget. The first results achieved through EFSI's support for RDI are very promising, especially for innovative SMEs and small midcaps via EFSI's SME Window.

Indeed, the EFSI SME window has significantly boosted support for technology and industrial innovation. The requirement is to target funds that focus on innovative SMEs and midcaps. By the end of 2015, 45 equity funds had been supported with a total EFSI / EIB investment of EUR 1.4 billion and mobilised investments estimated at EUR 14.5 billion, all for research and innovation.

Also, frontloading by EFSI of Horizon 2020's 'InnovFin SME Guarantee' facility, where demand is far greater than anticipated, had resulted by the end of 2015 in the signature of 21 guarantee or counter-guarantee schemes with banks and other lenders. This involves EFSI support of EUR 245 million, an expected total loans volume of around EUR 2.5 billion, and estimated mobilised investments of some EUR 3.9 billion, again all for innovative SMEs and small midcaps.

Looking at EFSI's Infrastructure / Innovation Window, 42 projects had been approved by the end of 2015 for an aggregate amount of EFSI finance of almost EUR 5.7 billion (very largely for loans), which is expected to mobilise more than EUR 25 billion of investments. Four projects are in the research and innovation sector priority and up to 21 more have a strong research and innovation component.

InnovFin is the new generation of EU financial instruments and advisory services that was launched by the European Commission, under Horizon 2020, and the EIB and EIF to help innovative firms access financing for research and innovation more easily. It is expected that the wide range of InnovFin debt and equity products on offer will make more than EUR 24 billion available to small, medium and large companies and the promoters of research infrastructures. This financing is expected to support up to EUR 48 billion of final research and innovation investments.

¹⁶ http://ec.europa.eu/priorities/jobs-growth-and-investment/investment-plan_en

PILLAR 3

MAXIMISING IMPACTS

In order to maximise the impact of EU policies, research and innovation programmes (including Horizon 2020) and other public funding sources, it is essential to simplify and create synergies between them so that excellent projects can access funding from different sources more easily. Identifying the best innovations to fund is also one of the challenges

that the Commission intends to tackle, including through the following initiatives.

Seal of Excellence

The Seal of Excellence¹⁷, launched by Commissioners Moedas and Cretu at the end of 2015, is a quality label awarded to project proposals submitted for funding under Horizon 2020 that succeeded in passing all of the selection and award criteria but which could not be funded with the available budget.

“The idea is very simple. Every year the Commission receives thousands of proposals that are submitted to Horizon 2020. All of these proposals are subject to a rigorous evaluation by independent experts. Only those that pass this evaluation are recommended for funding. Horizon 2020 is highly competitive. Unfortunately, many of these excellent proposals do not get funded by Horizon 2020 due to the limited budget available. The Seal of Excellence will be awarded to these excellent, but unfunded, proposals. This will allow other funding bodies to benefit from the Horizon 2020 evaluation results.

As a pilot phase, the ‘Seal of Excellence’ will start with the Horizon 2020 SME Instrument. As the name implies, this is specifically designed for SMEs to develop, test and produce innovative products and services.

We are launching a ‘Community of Practice’ with managing authorities and other funding bodies to build experience in implementing the ‘Seal of Excellence’.”

*Commissioner Carlos Moedas,
Ensuring Opportunity for All: Launch of the Seal of Excellence, Brussels, 12 October 2015*

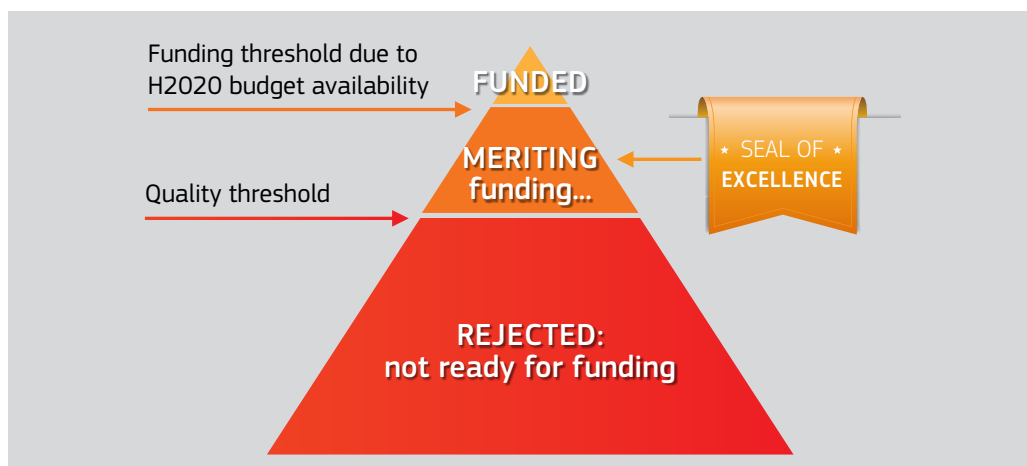
The Seal identifies promising project proposals and recommends them for funding from alternative sources, whether public or private, national, regional, European or international. The Seal of Excellence is a concrete example of moving from synergies in theory to synergies in practice, making the most of research and innovation investments, whatever their funding source, by mobilising different actors and encouraging them to interact, raising awareness and creating new opportunities, favouring efficient spending and therefore maximizing the impact of investment.

Regions and Member States (and any other interested funding organisation) can decide to support these proposals to fully exploit the outcomes of Horizon 2020’s world class evaluation system to the ultimate benefit of both the project proposer and of the local innovation eco-system.

With the Seal, funding authorities can easily identify for support proposals from promising innovative companies that want to grow and compete internationally. Regions and Member States can therefore more easily identify good quality proposals

¹⁷ <https://ec.europa.eu/research/regions/index.cfm?pg=soe>

Figure 01.6: Identifying proposals for the Seal of Excellence



that could be funded by European Structural and Investment Funds (ESIF) – in line with ESIF priorities and in compliance with national and relevant EU rules – or their own national or regional resources.

The Seal of Excellence certificate was first awarded to proposals to Horizon 2020's SME Instrument, which has a similar intervention logic to regional and national funders, with its focus on SMEs, the small size projects that are close to the market and its single beneficiary-approach.

All qualifying proposals made to the SME instrument since its launch (around 2 000 proposals by January 2016) have been awarded a Seal of Excellence certificate, and in the future, qualifying proposals will receive it systematically as soon as the evaluation results are communicated to them.

Meanwhile, in order to support the funding authorities and organisations that are interested in setting up support schemes compatible with the Seal of Excellence, the Commission established a *Community of Practice* to exchange good practice through regular meetings and an extranet site. Membership had already grown by January 2016 to 104 members, including ESIF managing authorities at national or regional level, funding agencies and private foundations from 23 Member States and one country associated to Horizon 2020. A number of countries and regions are themselves developing concrete support schemes.

Based on the outcome of this first implementation of the Seal of Excellence and on the requests received by the Commission, the Seal of Excellence may be extended in the future to cover more areas of Horizon 2020, starting with other mono-beneficiary schemes.

European Innovation Council

Time and time again it is said that Europe is a source of excellent science, but is losing the race with other industrialised economies on innovation. It is even more clear that Europe is behind the US and China when it comes to rolling out disruptive innovations, and turning its engineering and technological successes into world-beating brands. Scaling up businesses that pioneer new, market-oriented innovations is another area where Europe is behind its major competitors.

A number of positive steps have been taken in recent years to integrate an innovation component into EU programmes and policies, in particular Horizon 2020, which has encouraged higher levels of business participation than in the past. Nonetheless, the existing rather complex array of support mechanisms can be challenging for innovators (especially SMEs) to navigate.

Despite the considerable efforts which have already been undertaken to simplify administrative processes, there is a concern that EU support for

“Europe has excellent science, but we lack disruptive market-creating innovation. This is what is needed to turn our best ideas into new jobs, businesses and opportunities”

*Commissioner Carlos Moedas,
EU policy for the digital transformation of European business, Brussels, 16 February 2016*

innovation still lacks the responsiveness that innovators require in a time of ever-shortening innovation lifecycles. While Europe has excellent science, we lack sufficient disruptive market-creating innovation that is required to turn our best ideas into new opportunities, businesses and jobs. In order to address this shortcoming, the Commission is exploring the scope for establishing a European Innovation Council (EIC).

A well-designed, fit for purpose EIC would add value by meeting the needs of entrepreneurs and companies by converting knowledge and science into market-creating products and services, as well as by fostering a culture of entrepreneurship.

“Apart from putting the user at the centre, and enabling new players to enter traditional markets, the digital economy has the capacity to create entirely new markets. This is what Clayton Christensen calls “market creating innovations”. Think of Uber or AirBnB. These are platforms that link free capacity or spare capacity that already exists in society – extra houses or extra cars – with users that need them.

They are able to do this by being at the cutting-edge of the internet, apps, geolocation and mobile technology. They are successful, because they eliminate “pain points” in the interaction – for example, you do not have to have cash with you to use an Uber, and they are also successful because they just work – the design, the service, the process, is easy for the user.

No doubt these new services pose concrete challenges to our regulatory and tax systems. They raise questions of fairness and competition and these cannot be ignored, but my point is that these businesses enable economic transactions that would otherwise simply not happen. This is what I mean when I say that the digital creates new markets and enables a type of innovation that creates new economic opportunities.

Again, this is a force for the democratisation of innovation: empowering the sharing economy, promoting employment and even a more sustainable use of existing resources, which can be positive for the environment.”

*Commissioner Carlos Moedas, The democratisation of innovation,
Rome, 28 October 2015*

Merging the digital into societal challenges

Europe must act now to harness the potential of digitisation for its citizens, to tackle societal challenges effectively, and to boost its businesses and industries.

The opportunities and challenges in this area are growing. EU science, research and innovation policy plays an important part in merging the physical and digital worlds by exploiting the potential of digital technologies, such as big data analytics and the Internet of Things to deliver innovative solutions to societal

challenges in areas like health, energy, food and water. These four areas are the priorities for action.

Actions should also help create new business models and adjust existing ones, as 'physical-digital' innovations often entail new value-streams that blur the lines between products and services, consumption and production, online and offline. The overall aim is to increase the impact of Europe's investments on its innovation capacity, so as to better tackle societal challenges, increase our competitive advantage and create jobs.

E4Water – An example of Open Innovation in industry

Industry is one of the main water users in Europe, and one of the major polluters. The E4Water project is working towards a shift in industrial water treatment and management in the process and chemical industries. International partners, namely industry stakeholders, research organisations and end users, are developing innovative solutions for efficient, ecological and economical industrial water management. Open Innovation has driven the project from the very start: It combined the needs from industries to maximise resources and to minimise the environmental hazards for the population with solutions that brought both economic benefits and a greener industrial eco-system.

More than 200 stakeholders provided during a series of workshops the necessary inflows of knowledge that generated the outflows driving the innovations developed during the project. In addition, E4WATER carried out a broad consultation among stakeholders, including the private sector, public authorities, technology centres, European Technology Platforms, universities and end-users. Over 2 000 actors contributed with a wide variety of ideas and solutions to the existing challenges.

Based on that input, the E4WATER partners developed technological innovations for different industrial locations, in close consultation with the affected stakeholders. These solutions have had a direct impact in the environmental and water footprint by dramatically reducing the contaminants in the waste streams from those industrial parks. E4WATER's success mainly lies in the transfer of knowledge between industrial stakeholders and the cooperation with public authorities and end-users.

“I will work closely with Commissioner Hogan to create a Food Research Area with both EU and international partners by 2020.

The research area will focus on nutrition, climate, sustainability and economic growth. I want research and innovation to contribute to resilient food systems that provide responsible, affordable and healthy food for us all. The research area will operate on the basis of a multi-year research and innovation action plan that sets out our policy priorities; brings together new and existing initiatives and engages as wide a range of people and organisations as possible.

I want it to operate on the principles of Open Innovation and Open Science. I want it to be Open to the World. Ladies and gentlemen, food, water, health and energy, are the four areas I consider most important to our immediate future.”

*Commissioner Carlos Moedas,
Working together for global food and nutrition security, Expo Milano, 15 October 2015*

A second wave of Horizon 2020 simplification

If EU funding for research and innovation is to attract the best scientists and most innovative companies, the right balance must be struck between minimal bureaucracy for participants and effective oversight of the investment of taxpayers' euros.

Horizon 2020 was designed to simplify access to funding and reduce the administrative burden for participants in a project. This entailed major simplification compared to its predecessors, including a very simple cost reimbursement model, streamlined checks and audits and the fully electronic management of grants via a participant portal.

Further simplification is an ongoing objective. The Commission introduced some changes based on Horizon 2020's first year of operation, including simplified reporting requirements, and in autumn 2015 launched a major feedback exercise to collect ideas for a second wave of simplification of Horizon 2020. The online consultation generated over 4 700 replies. The main issues already identified include measures to reduce oversubscription, on the treatment of costs related to internal invoicing, and on the requirements for time-recording. Future simplification efforts may therefore include

an improved and more widely used two-stage proposal evaluation, a revision of the template and guidance for time-recording and a deeper analysis of the problems on internal invoicing, but also a continuation of the permanent process of improving the Participant Portal and the Commission's guidance, documentation and help services.

4. CONCLUSIONS

It is important to look beyond the current thinking to ensure that an innovation-friendly policy environment and an ecosystem which recognises the value of a broad approach to innovation are supported. This should include users in the innovation process and fostering the circulation of ideas and knowledge for innovation.

In the future, in addition to supply side measures, there should be more focus on addressing pro-actively the needs of European businesses so as to enable them to grow, engaging with knowledge users and citizens, and capitalising more efficiently on the knowledge base available in Europe. This would mean, for instance, engaging more with citizens, users, investors, businesses and business associations in a structured dialogue, and not only with universities and research-performing organisations.



Open
Science

OPEN SCIENCE

Open Science represents a new approach to the scientific process based on cooperative work and new ways of diffusing knowledge by using digital technologies and new collaborative tools. The idea captures a systemic change to the way science and research have been carried out for the last fifty years: shifting from the standard practices of publishing research results in scientific publications towards sharing and using all available knowledge at an earlier stage in the research process.

Open Science is to science what Web 2.0 was to social and economic transactions: allowing end users to be producers of ideas, relations and services and in doing so enabling new working models, new social relationships and leading to a new modus operandi for science. Open Science is as important and disruptive a shift as e-commerce has been for retail. Just like e-commerce, it affects the whole 'business cycle' of doing science and research – from the selection of research subjects, to the carrying out of research and to its use and re-use – as well as all the actors and actions involved up front (e.g. universities) or down the line (e.g. publishers).



A Vision of the Future

The year is 2030. Open Science has become a reality and is offering a whole range of new, unlimited opportunities for research and discovery worldwide. Scientists, citizens, publishers, research institutions, public and private research funders, students and education professionals as well as companies from around the globe are sharing an open, virtual environment, called The Lab.

Open source communities and scientists, publishing companies and the high-tech industry have pushed the EU and UNESCO to develop common open research standards, establishing a virtual learning gateway, offering free public access to all scientific data as well as to all publicly funded research.

The OECD as well as many countries from Africa, Asia, and Latin America have adopted these new standards, allowing users to share a common platform to exchange knowledge at a global scale.

High-tech start-ups and small public-private partnerships have spread across the globe to become the service providers of the new digital science learning network, empowering researchers, citizens, educators, innovators and students worldwide to share knowledge by using the best available technology.

Free and open, high quality and crowd-sourced science, focusing on the grand societal challenges of our time, shapes the daily life of a new generation of researchers.

Just as the internet and globalisation have profoundly changed the way we do business, interact socially, consume culture or buy goods, they are now profoundly impacting how we do research and science. We still listen to music today, but the way they are made (no longer only via traditional instruments) or sold (iTunes, Spotify) is radically different than 20 years ago, when the internet was hitting the music industry.

And just as people offer spare rooms via AirBnB, why shouldn't they be allowed to offer spare brain power via citizen science?

The discussion on broadening the science base and on novel ways to produce and spread knowledge gradually evolved from two global trends: *Open Access* and *Open Source*. The former refers to online, peer-reviewed scholarly outputs, which are free to read, with limited or no copyright and licensing restrictions, while *Open Source* refers to software co-created without any proprietary restriction and which can be accessed and used.

The Budapest Open Access Initiative of 2002¹⁸ established Open Access for the first time as an

internationally desirable publishing practice. Although Open Access became primarily associated with a particular publishing or scientific dissemination practice, the Budapest Open Access Initiative already sought to induce a broader Open Science practice that includes the general re-use of all kinds of research products, not just publications or data. But it is only more recently that Open Science has coalesced into the concept of a transformed scientific practice, shifting the focus of researchers' activity from '*publishing as fast as possible*' to '*sharing knowledge as early as possible*'.

Michael Nielsen's book '*Reinventing Discovery: The New Era of Networked Science*' is arguably the first and most comprehensive coverage of Open Science accessible to a broad readership¹⁹ Michael Nielsen advocated Open Science as "*the idea that scientific knowledge of all kinds should be openly shared as early as is practical in the discovery process*"²⁰. As a result, the way science is done in 2030 will look significantly different from the way it is done now.

¹⁹ Nielsen, Michael (2012): *Reinventing Discovery: The New Era of Networked Science*. Princeton University Press.

²⁰ The definition of Open Science was initially proposed by Michael Nielsen as an informal working definition on an Open Science mailing list '<https://lists.okfn.org/pipermail/open-science/2011-July/000907.html>', prior to the publication of his book. It very quickly received a large echo in the science community.

¹⁸ <http://www.budapestopenaccessinitiative.org/>

1. A DYNAMIC CONCEPT IN EVOLUTION

The European Commission's 2014 public consultation on *'Science 2.0: Science in Transition'*²¹ sought the views of major stakeholders to gain a better understanding of the full potential of 'Science 2.0'

and to assess any need for action. Stakeholders preferred the term 'Open Science' to describe the transformation of scientific practice.

"The days of keeping our research results to ourselves are over. There is far more to gain from sharing data and letting others access and analyse that data.

For example, if sharing big data reveals that a certain kind of cancer activates a particular molecular pathway in most cases and it turns out that there is already a drug approved and available to block the activation of that molecular pathway, clinical trials can begin almost immediately. Saving time, money and lives.

Or if scientists want to monitor the effects of climate change on local ecosystems, they can use Open Science to engage citizen reporting, and rapidly multiply the data at their disposal.

To make the most of Open Science opportunities for Europe, I plan to focus on open data, open access and research integrity over the course of my mandate."

*Commissioner Carlos Moedas,
"European research and innovation for global challenges", Lund, 4 December 2015*

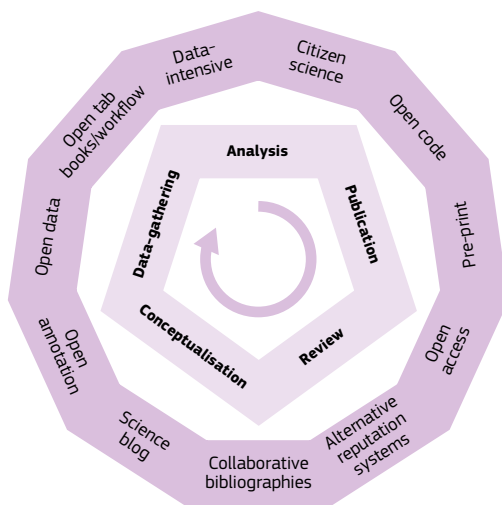
The background paper that served as the basis for the public consultation²² described Open Science as *'the on-going evolution in the modus operandi of doing research and organising science'*. This evolution is enabled by Big Data and digital technologies and is driven by both the globalisation of the scientific community and increasing public demand to address the societal challenges of our times. Open Science entails the ongoing transitions in the way research is performed, researchers collaborate, knowledge is shared, and science is organised.

Open Science has an impact on the entire research cycle, from the inception of research to its publication, and on how this cycle is organised. The outer circle in Figure OS.1 shows the new interconnected nature of Open Science, while the inner circle shows the entire scientific process, from the conceptualisation of research ideas to publishing. Each step in the scientific process is linked to on-going changes brought about by Open Science, such as the emergence of alternative systems to establish scientific reputation, changes in the way the quality and impact of research are evaluated, the growing use of scientific blogs, open annotation and open access to data and publications.

²¹ <http://ec.europa.eu/research/consultations/science-2.0/>

²² <http://ec.europa.eu/research/consultations/science-2.0/background.pdf>

Figure OS.1: Open Science – opening up the research process



Source: <http://ec.europa.eu/research/consultations/science-2.0/background.pdf>

All institutions involved in science are affected, including research organisations, research councils and funding bodies.

The trends are irreversible and they have already grown well beyond individual projects. They predominantly result from a bottom-up process driven by a growing number of researchers who increasingly employ social media for their research, to initiate globally coordinated research projects and share results at an early stage in the research process.

Fecher and Friesike (2013)²³ structure the overall changes encompassed by the term Open Science in five schools of thought: The *infrastructure school* which is concerned with the technological architecture, the *public school* which is concerned with the accessibility of knowledge creation, the *measurement school* which is concerned with alternative impact assessment, the *democratic school* which is concerned with access to knowledge and the *pragmatic school* which is concerned with collaborative research.

According to the measurement school, the reputation and evaluation of individual researchers is still mainly based on citation-based metrics. The Impact Factor (IF) – the most widely used being Thomson Reuter’s product – is a measure reflecting the average number of citations to articles published in an academic journal. It is used as a proxy for the relative importance of a journal. Numerous criticisms have been made of citation-based metrics, especially when (mis)used to assess the performance of individual researchers: often they are not applicable at the individual level; they do not take into account the broader social and economic function of scientific research; they are not adapted to the increased scale of research; and they cannot recognise new types of work that researchers need to perform.

Web-based metrics for measuring research output, popularised as “altmetrics” since 2010, have recently received a lot of attention: some measure the impact at article level, others make it possible to assess the many outcomes of research besides scientific articles (data, presentations, blog posts, mentions in social media etc.).

It is clear that the current reputation and evaluation system has to adapt to the new dynamics of

²³ Fecher, B. & Friesike, S. (2013). Open Science: One Term, Five Schools of Thought. In Bartling, S. & Friesike (Eds.), *Opening Science* (pp. 17–47). New York, NY: Springer.

Open Science and acknowledge and incentivise engagement in Open Science. Researchers engaging in Open Science have growing expectations that their work, including intermediate products such as research data, will be better rewarded or taken into account in their career development (see

examples in 'Recent milestones in the debate on Open Science'). Vice-versa, the (re)use of open data will require appropriate codes of conduct requiring, for example, the proper acknowledgement of the original creator of the data.

Recent milestones in the debate on Open Science

- The *San Francisco Declaration On Research Assessment* wants to put an end to the use of bibliometric parameters when deciding which researchers should receive grants or jobs. (December 2012)
- The Economist makes the problems in science a cover story ("How Science Goes Wrong"). It focuses on unreliable research and states that many errors in science go uncorrected. (October 2013)
- Nobel Prize winner *Randy Schekman* calls for a boycott of journals with high impact factors like *Science*, *Nature* and *Cell*. (December 2013)
- The *Reproducibility Initiative* wants to reproduce landmark studies since reproducing important papers in the current system is not rewarded, while it is of vital importance. (August 2012)
- Medical journal *The Lancet* wants to "increase value and reduce waste" in biomedical research. It discusses ways to do so in a series of articles. (January 2014)
- The *US National Institutes of Health* are exploring initiatives to restore the self-correcting nature of preclinical research. (January 2014)
- Promotion and grant committees should be reading through papers and judging research by its merit, says Nobel Prize winner *Sydney Brenner*. "I know of many places in which they say they need this paper in *Nature*, or I need my paper in *Science* because I've got to get a post doc. But there is no judgment of its contribution as it is." (March 2014)
- Biomedical science in the US needs to be rescued from its "systemic flaws", write *Bruce Alberts and Harold Varmus* in *PNAS* (March 2014). One of their recommendations is "to gradually reduce the number of entrants into PhD training in biomedical science – producing a better alignment between the number of entrants and their future opportunities – and to alter the ratio of trainees to staff scientists in research groups."
- Academic environments often place more value on the discovery itself and less value on learning how to realize the potential benefit of its application. This should change, universities should foster implementation science, write three doctors in the *New England Journal of Medicine*. (May 2014)
- In July 2014 the European Commission starts an online "Public consultation 'Science 2.0': Science in Transition" about the changing science system. The Science in Transition initiative features prominently in the background analysis. "In the Netherlands, an intensive debate has evolved on the basis of a position-paper entitled 'Science in Transition'. The ongoing debate in the Netherlands addressed, among others, the issue of the use of bibliometrics in relation to the determination of scientific careers."

- *Former Secretary General of the European Molecular Biology Organization **Gottfried Schatz** analyses the effects of Big Science in an essay in Nature Reviews Molecular Cell Biology. The exponential growth of science has led to meaningless quantification, a crisis in peer review, reproducibility problems and the rise of fellowships. (May 2014)*
- *Modify reward system for science to create reproducible and translatable research, says John Ioannidis in **PLoS Medicine**. With the current reward system “an estimated 85% of research resources are wasted”. (October 2014)*
- *Science should strive for “impact, not impact factor”, says **PNAS Editor-in-Chief Inder Verma**. “When it comes to judging the quality and significance of a body of work, there is no substitute for qualitative assessment. And it bears repeating that the impact factor is not an article-level metric, nor was it intended as a yardstick for comparing researchers’ scholarly contributions. However, at many institutions performance assessments hinge greatly on this number, which currently wields outsize influence on the advancement of scientific careers.” (June 2015)*
- *In an extensive review about quantitative indicators, ‘**The Metric Tide**’, a committee chaired by James Wilsdon in the UK concludes: “There is legitimate concern that some indicators can be misused or ‘gamed’: journal impact factors, university rankings and citation counts being three prominent examples.” (July 2015)*
- *In **PNAS** two researchers “[S]how that biomedical research outcomes over the last five decades, as estimated by both life expectancy and New Molecular Entities approved by the Food and Drug Administration, have remained relatively constant despite rising resource inputs and scientific knowledge.” (July 2015)*

Source: adapted from www.scienceintransition.nl

References to the articles in question are listed in the Credits section at the end of the book

The vision in action

An early and well-known example of Open Science is the Human Genome Project that started in 1990. The data on the human genome was widely shared among the scientific community in the course of the project, while at the same time they kept a moratorium on publishing in order to encourage optimal collaboration. Because of this openness, this enabled them to decode the human genome in less than 15 years.²⁴ Open Science in action has shifted the prime focus of researchers away from publishing towards knowledge sharing. The project has also had a considerable economic impact.²⁵

The ongoing changes are progressively transforming scientific practices and innovative tools to facilitate communication, collaboration, and data analysis are appearing (see section *A new ecosystem for Open Science*). Researchers increasingly work together to create knowledge. Online tools create a shared space where creative conversation can be scaled up. As a result, the problem-solving process can be faster and the range of problems that can be solved can be expanded (Nielsen 2012).

The ecosystem underpinning Open Science is evolving very rapidly. Social network platforms for researchers already attract millions of users and

²⁴ See e.g.: http://www.ngfn.de/de/verstehen_der_menschlichen_erbsubstanz.html

²⁵ Studies on the economic value of the Human Genome Project summarise that for each 1 US Dollar invested in the project 141 US Dollar were generated:

Battelle Memorial Institute, 2011 [online]: [http://battelle.org/media/press-releases/S3.8b-investment-in-human-genome-project-drove-\\$796b-in-economic-impact-creating-310-000-jobs-and-launching-the-genomic-revolution](http://battelle.org/media/press-releases/S3.8b-investment-in-human-genome-project-drove-$796b-in-economic-impact-creating-310-000-jobs-and-launching-the-genomic-revolution)

Battelle Memorial Institute, 2013 [online]: <http://www.battelle.org/media/press-releases/updated-battelle-study-genetics-and-genomics-industry>

are being used to begin and validate more research projects in a “brain sourced” way (Crouzier 2015²⁶).

A prominent example of “brain-sourced” research is the Polymath Project.²⁷ In 2009, Tim Gowers, a mathematician at Cambridge University, took an unsolved mathematical problem and published it in

his scientific blog in order to tackle it in a completely open way with anyone allowed to contribute. Only 37 days after the start of the project, Gowers announced that the on-line contributors had solved not just his original problem, but a harder problem that included the original as a specific example.

A new ecosystem for Open Science

Academia.edu is a US-based platform for academics to share research papers, monitor deep analytics around the impact of their research, and track the research of academics they follow. By January 2016, over 30 million academics had signed up to the site, which has over 36 million unique visitors a month. A recent study found that papers uploaded to Academia.edu receive a 73% boost in citations over five years.

Research Gate, based in Berlin, has virtually identical functions to Academia.edu, however it generates a Research Impact Factor for the uploaded documents of researchers, based on factors such as ‘classical’ citations and on the number of downloads by other users. It had 8 million users in January 2016 with 80 million publications available.

Mendeley is an Amsterdam-based reference manager. Apart from the ‘Facebook for Scientists’ features, Mendeley also allows for open annotation and generation of bibliographies. With around 3 million users (June 2014), Mendeley was purchased by the Elsevier publishing company in 2013.

Figshare is an online digital repository where researchers can make their research outputs available in a citable, shareable and discoverable manner, including figures, datasets, images and videos. It is now financially supported by Digital Science, a division of Macmillan Publishers.

F1000Research is an Open Science publishing platform for life scientists, offering immediate publication without editorial bias. The traditional anonymous pre-publication peer review of research articles can cause long delays before new results become visible. F1000Research uses an author-led process, publishing all scientific research within a few days. Open, invited peer review of articles is conducted after publication, focusing on scientific soundness rather than novelty or impact. All published research articles are accompanied by the data on which the reported results are based, which is crucial to enable reanalysis, replication attempts and data reuse.

Though impressive, the numbers mentioned in the section *A new ecosystem for Open Science* do not reflect the degree of awareness and the adoption rates of the most innovative tools such as social networks,

collaborative writing tools or blogs for researchers. Recent reports still show a considerable lack of awareness of Open Science among researchers.²⁸

²⁶ Crouzier, Thomas (2015): Science Ecosystem 2.0: how will change occur? http://ec.europa.eu/research/innovation-union/pdf/expert-groups/rise/science_ecosystem_2.0-how_will_change_occur_crouzier_072015.pdf#view=fit&pagemode=none

²⁷ <http://polymathprojects.org/>

²⁸ Pscheida, D. et al, (2014): Nutzung von Social Media und onlinebasierten Anwendungen in der Wissenschaft. Leibniz Forschungsverbund Science 2.0 Vignoli, Michela et al (2014): YEAR Consultation on Science 2.0. [online]: https://scienceintransition.files.wordpress.com/2014/12/year_consultation_science-2dot0_v1-0.pdf

However, fuelled by the new opportunities for knowledge and data-sharing, more Open Science practices have emerged to address pressing issues at an early stage. For example, five months into the largest Ebola outbreak in history, an international group of researchers sequenced three viral genomes, sampled from patients in Guinea. The data was made public that same month.²⁹ The National Institutes of Health in the United States now require grantees to make large scale genomic data public by the time of publication at the latest.³⁰

In the EU, steady progress towards Open Science has also been made, in some cases thanks to EU-funded activities (see the section *Data sharing in public health emergencies*). The ‘European Lead Factory’ project under the Innovative Medicines Initiative (IMI) is a very good example of Open Science because in this project, academic and industry partners are pooling together around half a million compounds (chemical molecules). This is unique and has never been achieved before in Europe, either between academic and industry or between companies themselves. Secondly the 500,000 compounds are publicly and freely available in a repository to

any scientist who wants to screen and validate a potential new drug target. The costs of screening are covered by the project.

Two European research projects in environmental science aim to put the latest results from ecosystem research into practice. They have created an open platform accessible to the wider public to provide tested, practical and tailored solutions for environmental management and decision-making and to help stakeholders to apply the ecosystem services and research results into concrete actions (see the section *Open Science in Action: open platforms for the support of scientists and decision makers*). The Climate Joint Programme Initiative³¹ supported by the 7th Framework Programme fosters the free flow of knowledge and information to help mutual learning (see see the section *JPI Climate: Open Science tackling a societal challenge*).

These examples also demonstrate policymakers’ engagement in encouraging data-sharing among the relevant actors in various fields, such as public health or climate change for example.

Data sharing in public health emergencies

When scientists and policy makers talk about data sharing this often refers to the data underlying scientific publications. But in public health emergencies such as the recent Ebola epidemic, public health officials and patients cannot afford the time lag of scientific publications. Data, such as that on the evolution of the Ebola virus or on clinical trials of anti-Ebola treatments, needs to be shared at a very early stage with public health decision makers, clinicians and other researchers, who can build on it to deliver solutions for patients.

The European Commission has strongly supported the World Health Organisation in its efforts to agree on standards for such data sharing in public health emergencies. The Commission-led ‘Global Research Collaboration for Infectious Disease Preparedness’ (GloPID-R) is looking at ways to encourage and oblige researchers funded by Horizon 2020 (and other funding programmes) to comply with such global norms in data sharing in public health emergencies.

²⁹ N.L. Yozwiak et al (2015) <http://www.nature.com/news/data-sharing-make-outbreak-research-open-access-1.16966>

³⁰ <https://gds.nih.gov/>

³¹ <http://www.jpi-climate.eu/home>

Open Science in Action:

Open platforms for the support of scientists and decision makers

Two projects funded by the 7th Framework Programme for Research: OpenNESS (Operationalization of natural capital and ecosystem services)³² and OPERAs (Operational Potential of Ecosystem Research Applications)³³ are creating an 'Open Platform' (OPPLA), a truly 'open' fee-free platform for individual users not seeking to commercialise data/products already in the public domain.

It will provide a number of facilities to support scientists, policymakers, consultants, businesses, environmental NGOs, land managers, spatial planners and economists, in making nature work for people by mainstreaming innovative research results into daily practice and promoting collaborations and co-creation processes. The outcome of the projects will contribute to the 'operationalization of natural capital and ecosystem services' and, in consequence, to the further promotion of nature-based solutions to address societal challenges, an initiative currently pursued through Horizon 2020. OPPLA will provide practical advice, guidance, tools and techniques, a database of information and case studies to the broad range of stakeholders and users mentioned above. It will in addition provide an open 'Question & Answer' facility related to natural capital and ecosystem services, a "marketplace" enabling members to find, among others, consultants specialising in natural capital and ecosystem services, to help with their own projects and a helpdesk. The "community of practice" that is expected to be established through this platform will have the possibility to share resources, new ideas and practical experience and get informed about relevant events, training courses and have access to other services on demand. Oppla is built for and by its users since the latter will have the opportunity to actively contribute to its further development towards, among others, provision of services such as self-certification of products and services and crowd-sourced enquiry (Ask Oppla).

JPI Climate:

Open Science tackling a societal challenge

The Climate Joint Programming Initiative (JPI) is a collaboration between 16 European countries to coordinate jointly their climate research and fund new transnational research initiatives. JPI Climate connects scientific disciplines, enables cross-border research and increases science-practice interaction. It integrates European climate change science and connects it to efforts in Europe to be both climate friendly (through mitigation) and climate proof (through adaptation) by coordinating and developing excellent science, industrial leadership and transnational collaboration. Five framing principles guide the ongoing work and further development of JPI Climate: stakeholder orientation, transparency, cost effectiveness, sustainability, adaptability.

According to the transparency principle all collaborative efforts are based on the notions of openness, mutual learning, mutual dependency and joint creativity; and foster the free flow and sharing of information, experiences and opinions. Access to knowledge and information is a prerequisite for individual and mutual learning processes. Given the huge and complex societal challenge that is addressed by JPI Climate, fostering both is a prerequisite to its success.

³² <http://www.openness-project.eu/>

³³ <http://operas-project.eu/>

2. THE LINK TO OPEN INNOVATION AND OPEN TO THE WORLD

Open Science permits knowledge to circulate more quickly and be more freely available. The Commission's policy actions on Open Science will reinforce the EU's political priority of fostering knowledge circulation, since Open Science is in practice about 'sharing knowledge as early as practically possible in the discovery process'³⁴. Furthermore, the trends towards Open Access are redefining the framework conditions for science and thus have an impact on how (Open) innovation is produced by encouraging a more dynamic circulation of knowledge. It can enable more science-based start-ups to emerge thanks to the exploitation of openly accessible research results.³⁵

Open Science, however, does not mean 'free science'. It is essential to ensure that intellectual property is protected before making knowledge publicly available in order to subsequently attract investments that can help translate research

results into innovation. If this is taken into account, fuller and wider access to scientific publications and research data can help to accelerate innovation. The potential benefits of opening up research information are clearly recognised in the European Commission's investment plan for Europe where it is stated that in order to '*boost research and innovation, EU competitiveness would benefit from fewer barriers to knowledge transfer, open access to scientific research and greater mobility of researchers*'.³⁶

In this context, Open Access can help overcome the barriers that innovative companies, in particular SMEs, face in accessing the results of research funded by the public purse. It has been estimated that switching to open access could result in annual savings of around £400 million for the UK, €133m for the Netherlands and €80m for Denmark.³⁷

A healthy knowledge economy relies on the quantity, quality and accessibility of data. In the 21st century, we can be sure that means quantity of data on an international scale, across international research institutions. We can be sure that the quality of data will be vetted by scientists from across the globe thanks to global communications and we can be sure that the accessibility to data will become: increasingly universal, increasingly open, and require new business models.

Therefore, any European knowledge economy of the future must be swift to adapt and Open to the World.

*Commissioner Carlos Moedas,
Promoting excellence through enhanced EU-China researcher mobility and cooperation,
Beijing, 7 September 2015*

³⁴ Nielsen 2012

³⁵ H. Chesbrough, From Open Science to Open Innovation, Science|Business Publishing 2015, <http://www.sciencebusiness.net/eventsarchive/OpenScience/>

³⁶ Communication 'An Investment Plan for Europe' COM(2014)903 final, p.16. <http://ec.europa.eu/transparency/regdoc/rep/1/2014/EN/1-2014-903-EN-F1-1.Pdf>

³⁷ Houghton et. al (2009) Economic implications of Alternative Scholarly Publishing Models: Exploring the Costs and Benefits. Swan, A. (2010) Modelling scholarly communication options: costs and benefits for universities.

Data is becoming increasingly important in all areas of the European economy. The European Bioinformatics Institute (EMBL-EBI) located on the Wellcome Genome Campus in Hinxton, UK and among others funded by the European Commission, provides a good example of the economic impact of opening up research data. EMBL-EBI manages public life-science data on a very large scale, making a rich resource of information freely available to the global life science community. A recent study has valued the benefits of EMBL-EBI to users and their funders at £1 billion (approximately EUR 1.26 billion) per year worldwide – equivalent to more than 20 times the direct operational cost of the institute. The report estimates that EMBL-EBI data and services contributed to the wider realisation of future research impacts worth £920 million (approximately EUR 1.16 billion) every year.³⁸

Open Science is a global phenomenon and many countries outside Europe such as Japan, research funders including the United States National Institutes of Health and foundations such as the Bill and Melinda Gates Foundation are also developing Open Science initiatives. Japan³⁹ has been clearly influenced by the European Commission's initiatives on Open Science and the United States has been developing Open Data policies at institutional levels since 2003 (see the section *National Institutes of Health (NIH-USA) Data Sharing policy and guidance*). Differences in approach are generally seen in modalities such as the length of embargo periods prior to open access publication. The open access policy of foundations such as the Bill and Melinda Gates Foundation are similar to those of the European Commission (see the section *Open Access and the Bill & Melinda Gates Foundation*).

National Institutes of Health (NIH-USA) Data Sharing policy and guidance²³

Data sharing promotes many goals of the NIH research endeavour. It is particularly important for unique data that cannot be readily replicated. Data sharing allows scientists to expedite the translation of research results into knowledge, products, and procedures to improve human health.

There are many reasons to share data from NIH-supported studies. Sharing data reinforces open scientific inquiry, encourages diversity of analysis and opinion, promotes new research, makes possible the testing of new or alternative hypotheses and methods of analysis, supports studies on data collection methods and measurement, facilitates the education of new researchers, enables the exploration of topics not envisioned by the initial investigators, and permits the creation of new datasets when data from multiple sources are combined.

In the NIH's view, all data should be considered for data sharing. Data should be made as widely and freely available as possible while safeguarding the privacy of participants, and protecting confidential and proprietary data. To facilitate data sharing, investigators submitting a research application requesting \$500,000 or more of direct costs in any single year to NIH on or after October 1, 2003 are expected to include a plan for sharing final research data for research purposes, or state why data sharing is not possible.

³⁸ <http://www.beagrie.com/static/resource/EBI-impact-summary.pdf>

³⁹ http://www8.cao.go.jp/cstp/sonota/openscience/150330_openscience_summary_en.pdf

⁴⁰ http://grants.nih.gov/grants/policy/data_sharing/data_sharing_guidance.htm

Open Access and the Bill & Melinda Gates Foundation

The Open Access policy²⁴ of the Bill & Melinda Gates foundation contains the following elements:

1. ***Publications Are Discoverable and Accessible Online.*** Publications will be deposited in a specified repository(s) with proper tagging of metadata.
 2. ***Publication Will Be On “Open Access” Terms.*** All publications shall be published under the Creative Commons Attribution 4.0 Generic License (CC BY 4.0) or an equivalent license. This will permit all users of the publication to copy and redistribute the material in any medium or format and transform and build upon the material, including for any purpose (including commercial) without further permission or fees being required.
 3. ***Foundation Will Pay Necessary Fees.*** The foundation would pay reasonable fees required by a publisher to effect publication on these terms.
 4. ***Publications Will Be Accessible and Open Immediately.*** All publications shall be available immediately upon their publication, without any embargo period. An embargo period is the period during which the publisher will require a subscription or the payment of a fee to gain access to the publication. We are, however, providing a transition period of up to two years from the effective date of the policy (or until January 1, 2017). During the transition period, the foundation will allow publications in journals that provide up to a 12-month embargo period.
 5. ***Data Underlying Published Research Results Will Be Accessible and Open Immediately.*** The foundation will require that data underlying the published research results be immediately accessible and open. This too is subject to the transition period and a 12-month embargo may be applied.
-

Science International, which brings together representatives of four major international science organisations, is responding to a growing number of calls from various actors, both within and outside the scientific community, and from inter-governmental bodies such as the G8, the OECD and the UN, for open access to publicly-funded scientific data, especially regarding data of particular importance to major global challenges.

Science International is therefore developing a plan for a global discussion on Open Science in general and for a data science capacity in Africa. The European initiatives to establish an Open Science Policy Platform and to create a European Open Science Cloud (see below) have provided the inspiration for this global activity.

⁴¹ <http://www.gatesfoundation.org/How-We-Work/General-Information/Open-Access-Policy>

3. OPEN SCIENCE IN THE COMMISSION'S NEW PRIORITIES

In accordance with the political priorities of Commissioner Moedas⁴² and as a result of its 2014 public consultation, in 2015 the European Commission identified five lines of potential policy actions to support the development of Open Science in Europe. The potential interventions build on the expectation that Open Science will eventually lead to better science, by making science more credible (addressing scientific integrity), reliable (better and more transparent verification of data), efficient (avoid duplication of resources) and more responsive to societal challenges.

The five lines of potential policy actions are:

1. *Fostering and creating incentives for Open Science*, by fostering Open Science in education programmes, promoting best practices and increasing the input of knowledge producers into a more Open Science environment (citizen science). This area is also concerned with guaranteeing the quality, impact and research integrity of (Open) Science;
2. *Removing barriers to Open Science*: this implies, among other issues, a review of researchers' careers so as to create incentives and rewards for engaging in Open Science;
3. *Mainstreaming and further promoting open access policies* as regards both research data and research publications;
4. *Developing research infrastructures for Open Science*, to improve data hosting, access and governance, with the development of a common framework for research data and creation of a European Open Science Cloud, a major initiative to build the necessary Open Science infrastructure in Europe; and,
5. *Embedding Open Science in society as a socio-economic driver*, whereby Open Science becomes instrumental in making science more responsive to societal and economic expectations, in particular by addressing major challenges faced by society.

The European Commission has stated its intention to establish an Open Science Policy Platform in 2016 and several expert groups to propose recommendations for developing Open Science policy through a structured discussion with all the relevant actors involved in science and research in Europe.

This dialogue constitutes an opportunity to develop, guide and monitor Open Science with the involvement of the people who practice it.

The Open Science Policy Platform will be composed of representatives of European umbrella organisations representing the major stakeholder groups of universities, research funding bodies, research-performing organisations, citizen science, associations of scientific publishers, academies of science, Open Science platforms and intermediaries, and (research) libraries.

The Open Science Policy Platform will advise the Commission on the development and implementation of cross-cutting issues concerning Open Science in line with the five broad lines of policy actions. Several expert groups will address the following issues: rewards for researchers, altmetrics, the European Open Science Cloud, changing business models for publishing, research integrity, Citizen Science, open education and skills, and FAIR Open Data.

The expert groups are being launched in phases. In 2015, the Commission's Directorate-General for Research and Innovation launched working groups on Altmetrics and on the European Open Science Cloud.

The establishment of a European Open Science Cloud under the Digital Single Market strategy of the European Commission⁴³ is a key part of Europe's ambition to support the transition to Open Science and to make the most of data-driven science. The aim is to make relevant research data findable, accessible, interoperable and re-useable ('FAIR') to all European researchers. The Cloud will bring together existing and emerging data infrastructures to create a virtual environment for all European researchers to store, manage, analyse and re-use data.

⁴² http://europa.eu/rapid/press-release_SPEECH-15-5243_en.htm

⁴³ http://ec.europa.eu/priorities/digital-single-market_en

The European Open Science Cloud

The European Open Science Cloud aims to create a trusted European environment for hosting and processing research data to help maintain the world-leading role of European science.

It will be achieved by creating a world-class scientific infrastructure, which will help ensure that European stakeholders reap the full benefits of data-driven science and services for the digital economy and wider society.

The Cloud will offer 1.7 million European researchers and 70 million professionals in science and technology a virtual environment with open and seamless services for the storage, management, analysis and re-use of data that is linked to their research activities, across borders and scientific disciplines. It will be free at the point of use.

This initiative is part of Europe's ambition to support the transition to Open Science in the context of the Digital Single Market. It aims to meet an urgent need of the scientific community to increase access to and re-use of data, and to reduce the cost of data storage and high-performance analysis by pooling existing capacity and by aggregating demand, initially by researchers in the public sector.

The initiative will increase awareness of the value of data and the potential of Open Science, and help boost the range of incentives for academics, industry and public services to share their data as widely as possible. It will enable interoperability for data sharing, long-term accessibility and re-use through integrated and sustainable infrastructures accessible across disciplines in both public and private areas. It will address the challenges of fragmentation by federating scientific infrastructures in the virtual environment of the cloud, to increase efficiency, rationalise efforts and reduce costs through its pan-European governance.

Overall, the European Open Science Cloud will increase capacity, consolidate scientific services and strategically govern resources:

- Cloud-based services for Open Science enabling researchers to openly share and analyse research data across technologies, disciplines and countries. The service dimension will foster, implement and mainstream initiatives driven by the scientific community to harmonise and bridge data standards, policies, technologies, infrastructures and communities.

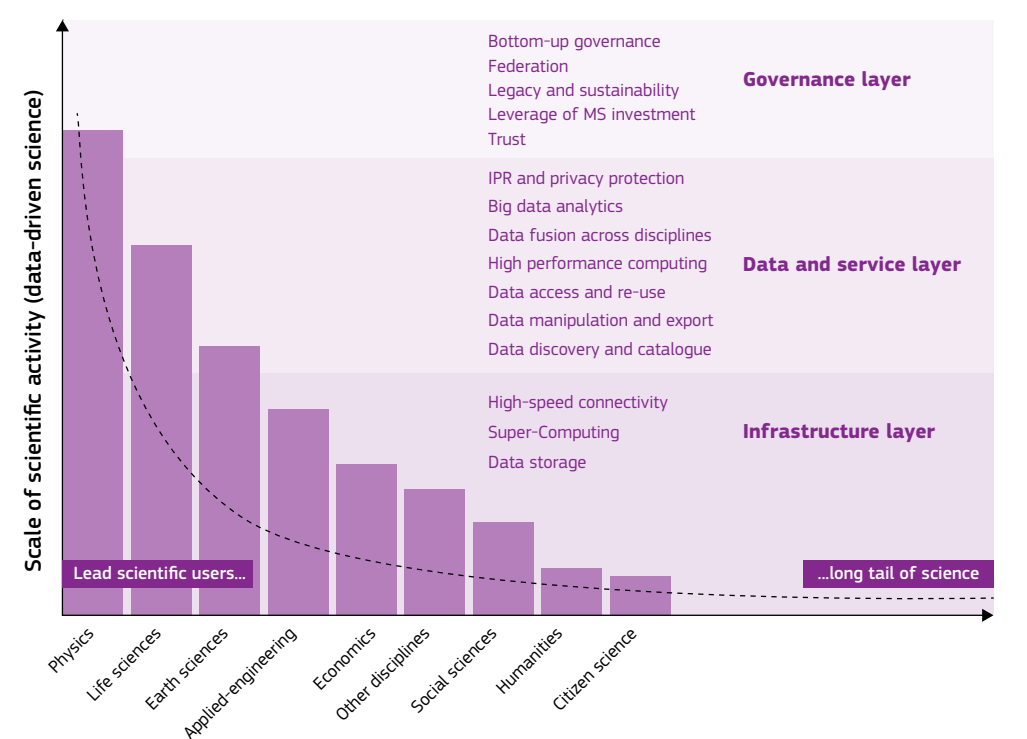


- Governance platform for policy development on infrastructure and services, mechanisms for global data stewardship, decision making on funding and long-term sustainability. The governance will involve scientific users, research funders and implementers, building on existing governance structures, such as ESFRI, eIRG, GEANT, PRACE, ELIXIR, Belmont Forum and other similar federating initiatives.

The initiative reinforces Open Science, Open Innovation and Open to the World policies. It will foster best practices of global data findability and accessibility (FAIR data), help researchers get their data skills recognised and rewarded (careers, altmetrics); help address issues of access and copyright (IPR) and data subject privacy; allow easier replicability of results and limit data wastage e.g. of clinical trial data (research integrity); contribute to clarification of the funding model for data generation and preservation, reducing rent-seeking and priming the market for innovative research services e.g. advanced TDM (new business models).

In some disciplines that rely heavily on big data sets, such as physics and life sciences, scientists are already making use of advanced data infrastructures to store, share and analyse data. Conversely, more dispersed or ‘analogue’ scientific communities, such as citizen scientists, researchers in the humanities or those working in less-developed areas where limited data is available (such as rare diseases or genomics of rare species), are just starting to experiment with local solutions to the same problem, based on smaller and simpler datasets. This is commonly referred to as ‘the long tail of science’. The data and service layer of the European Open Science Cloud will provide common solutions for data storage, sharing and analysis for all types of scientific communities. Indeed, existing tools and expertise from leading scientific disciplines may benefit the long tail, while greater overall demand may increase data quality and make the joint procurement of services cheaper, as well as providing other benefits. Since the Cloud can potentially provide benefits for all types of scientific communities, its governance structure should reflect their various and specific needs (see Figure OS.2).

Figure OS.2: Governance of the European Open Science Cloud



Source: DG Research and Innovation (2015)

The Open Science Policy Platform will advise the Commission, based on bottom up discussion and analysis of best practices, on the policy actions necessary to ensure that Open Science fulfils its potential to radically increase the quality and impact of European research. And to ensure that any policy discussions are based on the latest information, in 2016 the Commission will also set up an *Open Science Monitor* which will identify, quantify and assess the quality of all the ongoing trends in Open Science, thus providing the

European Commission with up-to-date information on the rapidly changing Open Science environment.

Advancing Open Access and Data Policies

The European Commission sees Open Access not as an end in itself but as a tool to facilitate and improve the transparency and circulation of scientific information in Europe and ultimately, to produce even more high quality science and contribute to better policy making.

We need to shift our focus from publishing as soon as possible, to sharing and collaborating as soon as possible. Public investment in research and innovation should have the greatest social and economic benefits possible: improving the public relationship with our science systems and opening research results to new innovation and business opportunities. Big and open data alone could be worth an extra 1.9% to EU-28 GDP by 2020. To remain prosperous and competitive, to continue leading the forefront of learning, this is an opportunity we simply cannot afford to miss... Expensive fees for publicly funded research results that could be of benefit to citizens, must end, and new business models put in place.

Commissioner Carlos Moedas, Freedom is absolutely necessary for scientific progress, Brussels, 26 January 2015

Publicly funded knowledge must be available for researchers and the private sector to enhance the knowledge base, reduce regional disparities in terms of research, promote new technologies and products, and produce innovative solutions to societal challenges. Unrestricted and free of charge access to publications is backed by a growing number of universities, research centres and funding agencies across Europe.

In 2012, therefore, the Commission published a comprehensive package of policy measures to improve access to scientific information produced in Europe.⁴⁴ Furthermore, Open Access to publications is now mandatory for research results arising from

projects funded by Horizon 2020, which has also launched a pilot initiative on Open Research Data.⁴⁵

Almost all Member States have set up legal and administrative rules to support “Open Access” to scientific publications, and some are also promoting Open Access to data.⁴⁶ Generally there are two models of Open Access to publications: Green (self-archiving) and Gold (open access publishing). Most EU Member States prefer one or other model, but not always exclusively so, often resulting in a mix of both models being applied. Few Member States have laws requiring open access to publications, however a single institution may make it mandatory, for example

⁴⁴ Communication ‘A Reinforced European Research Area Partnership for Excellence and Growth’ COM(2012)392; Communication, ‘Towards better access to scientific information’ COM(2012)401; Commission Recommendation on access to and preservation of scientific information COM(2012)4890).

⁴⁵ <http://ec.europa.eu/research/openscience/index.cfm?pg=openaccess>

http://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/open-access-dissemination_en.htm

⁴⁶ Commission SWD “ERA Facts and Figures 2013”, p. 28

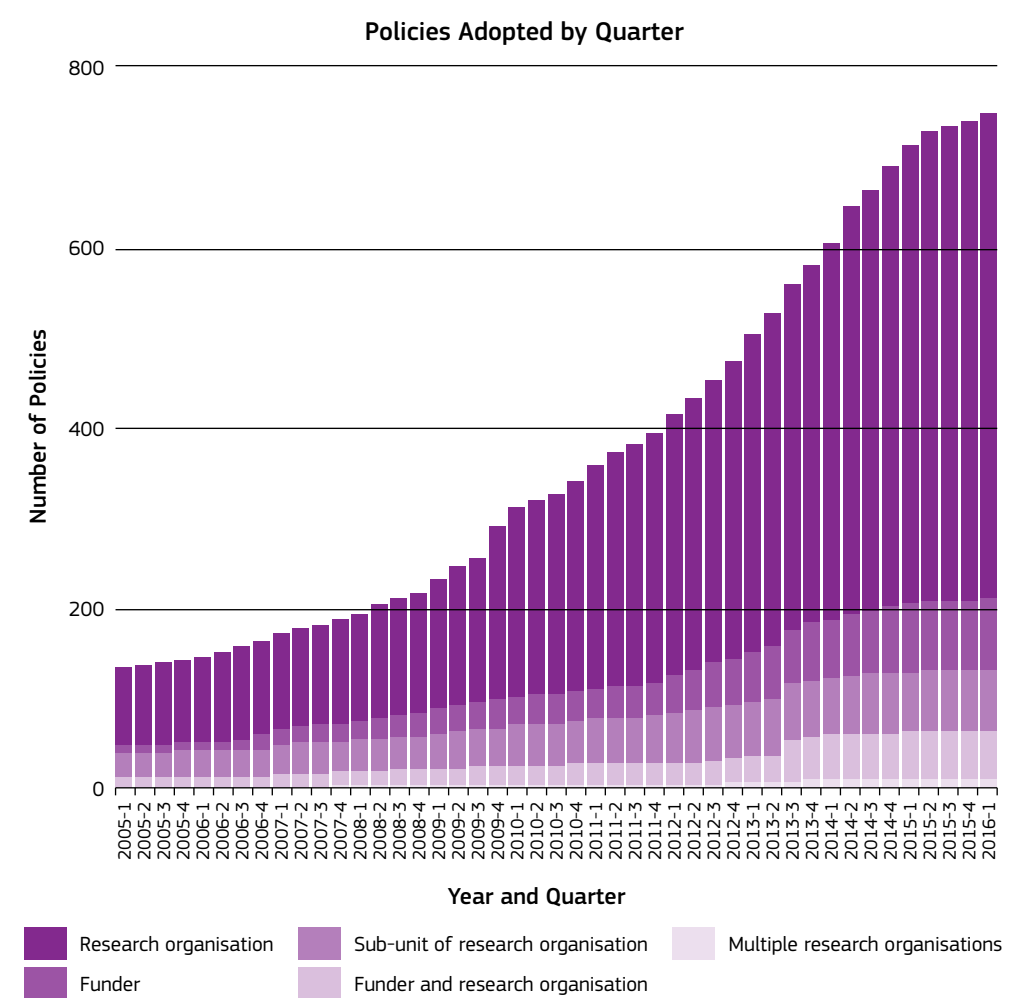
by making Open Access a condition of funding or a positive evaluation of a researcher's career.⁴⁷

In 2014 the Finnish Ministry of Education and Culture published an ambitious Open Science and research roadmap. Based on the assumption that Open Science and research can lead to surprising discoveries and creative insights, Finland is promoting initiatives to open up the information produced by publicly funded research (publications, data and methods) by fostering open publication, open peer review, parallel archiving under open

licences while ensuring the quality, discoverability and usability of research results.⁴⁸

The Registry of Open Access Repository Mandates and Policies (ROARMAP)⁴⁹ charts the growth of open access mandates and policies globally. There has been a steady increase between 2005 and 2015 in the number of registered policies adopted by universities, research institutions and research funders that require or request researchers to provide open access to their peer-reviewed research articles by depositing them in an open access repository (see Figure OS.3).

Figure OS.3: Growth of Open Access Repository Mandates and Policies



Source: <http://roarmap.eprints.org/>

⁴⁷ European Commission (forthcoming). Access to and Preservation of Scientific Information in Europe. Report on the implementation of Commission Recommendation C(2012) 4890 final

⁴⁸ <http://openscience.fi/>

⁴⁹ <http://roarmap.eprints.org/>

In general, Open Access should be considered in a broader context and needs to include a change in the scientific culture towards more openness, which could be achieved with encouragement and incentives. One incentive is to integrate Open Access in the evaluation of a researcher's career. At the University of Liège, for example, only publications deposited in the university's Open Repository and Bibliography repository⁵⁰ are taken into account in a researcher's career evaluation.⁵¹

The movement towards Open Access is transforming and broadening into the emerging practice of *open scholarly communication*, addressing not only publications and data, but also scholarly outreach, research assessment, online collaborative writing and even online collaborative discovery.⁵²

This may lead to the constitution of a scholarly commons allowing the free flow of knowledge and data throughout the entire research cycle, including discovery and analysis. This is going on now as the Wikimedia approach described in Figure OS.4 illustrates. At every level of the scholarly process new private and/or public initiatives are in place or being created that allow the scholarly process to be carried out differently and where the Wikimedia layer stands for the efforts to capture all this in a “commons”.

Such a commons, however, as illustrated by Figure OS.4, will compete with private initiatives offering particular services at the different stages of the research cycle, such as the research assessment services offered by commercial operators.

Figure OS.4: Open Science: From Open Access to Open Scholarly Communication



Source: <http://innoscholcomm.silk.co>

⁵⁰ <http://orbi.ulg.ac.be/>

⁵¹ http://www.ulg.ac.be/cms/c_17700/fr/open-access

<http://initiatives.exlibrisgroup.com/2013/05/a-mandate-for-open-access-university-of.html>

⁵² Bosman, Jeroen and Kramer, Bianca (2015): 101 innovations in scholarly communication. [online]: <http://innoscholcomm.silk.co/>

Text and Data Mining

Text and Data Mining (TDM) is a set of methods that use computers to automatically search, filter and interpret large amounts of digital and online content. Mining content to which researchers already have legal access is the automation of a process that researchers have otherwise done manually for hundreds of years. Since TDM is an emerging field that comprises a set of different methods, it is still difficult to quantify. Research is fragmented across more than 28,000 peer-reviewed journals from around 10,000 different publishers. In addition, the real benefits of TDM can be seen especially where the required content comes from multiple sources.⁵³

The European Commission estimates that the technological developments underpinning TDM will have advanced enormously by 2030, creating vast

amounts of new and heterogeneous digital data, arising from initiatives such as free and open data access policies, continued expansion of social media, real-time sensory data feeds as the Internet of things evolves as well as a result of new infrastructures and social platforms that allow experts and citizens to produce large volumes of data.⁵⁴

In order for the benefits that could be derived from these relatively new tools, techniques and technologies to be fully developed, the legal uncertainties across different fields of law, in particular copyright and database rights, need to be addressed. This was also one of the conclusions of an Expert Group on TDM convened by the European Commission in 2013 as only a few countries in the world have adopted or are in the process of adopting specific copyright provisions to introduce a data analysis exception (i.e. TDM exception) in their legislation.⁵⁵

Research-friendly copyright for Open Science and innovation in Europe

European researchers and innovators should have the explicit right to process on a large scale the content to which they have legal access. That is why the European Commission proposed on 9 December 2015 a mandatory exception for research in the EU copyright legislation.

This exception should overcome the current fragmented copyright regime across the EU, the lack of clarity around copyright and ownership of derived works, and the inadequacy of licensing solutions. These obstacles have so far hampered the use of technologies commonly known as Text and Data Mining (TDM) in the EU. As a result, researchers – especially those from public interest research organisations – have felt discouraged to use such techniques to analyse vast amounts of digital content. Scientific research is collaborative and knows no borders and Europe should not fall behind other regions of the world, where TDM is already made easy.

The harmonisation of the copyright exception for scientific research purposes was identified as key for the functioning of the Digital Single Market. The planned exception will help the scientific community and innovative companies that have established collaboration with them – in particular in the case of public-private partnerships – to make the best use of digital content they have already lawfully acquired or obtained access to. It will help bring coherence among the EU's 28 Member States and remove key barriers to Open Science and Open Innovation. Researchers and innovators should be given the best conditions to do their jobs. The exception proposed will be pivotal in spurring innovation and growth in Europe. The legislative package, including the exception for research, was launched in April 2016.

⁵⁴ <https://ec.europa.eu/digital-single-market/en/news/european-commission-foresight-fiches-global-trends-2030>

⁵³ <http://sparceurope.org/wp-content/uploads/2015/09/TDM-briefing-paper-final.pdf>

⁵⁵ http://ec.europa.eu/research/innovation-union/pdf/TDM-report_from_the_expert_group-042014.pdf

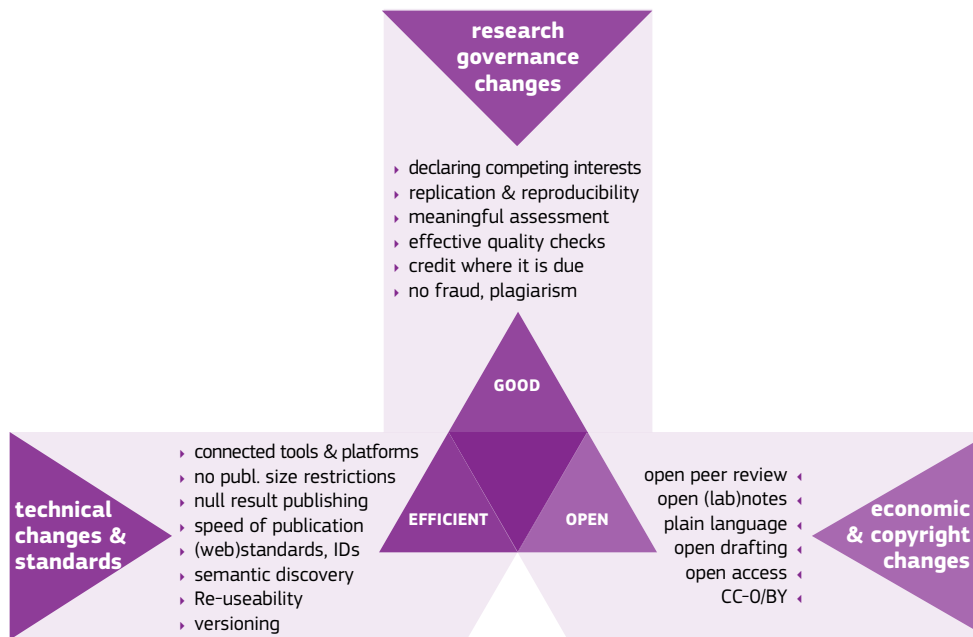
Towards better, more efficient and more Open Science

The impact of all these trends is already visible and already affecting some of the most burning issues in how research is carried out, such as the slowness of the publication process, increasing criticism of the existing peer review system, and the challenge of reproducing reliable research results, all of which

justify the demand that science should become more efficient.

Open Science has the potential to strengthen and enhance science by facilitating more transparency, openness, networking and collaboration, and by fostering interdisciplinary research. In being open, science will be fully accountable for its use of public resources.⁵⁶

Figure OS.5: Towards 'better science' – Good, efficient and Open Science



Source: <http://blogs.lse.ac.uk/impactofsocialsciences/2015/11/11/101-innovations-in-scholarly-communication/>

Open Science can transform science into 'better' science. Better science means making science (Figure OS.5):

- Good: by making science more credible and replicable, for example by addressing governance and scientific integrity;
- Efficient: by avoiding duplication of resources and optimising the re-useability of data; and,
- Open: by improving the accessibility of data and knowledge at all stages of the research cycle, and enabling text and data mining by ensuring the appropriate conditions within copyright law.

Fostering Research Integrity

The growing scrutiny of research integrity constitutes another key driver of Open Science. With evidence coming to light of some cases where research results appear to be not replicable⁵⁷, the re-use of data can help foster the replicability of studies.

⁵⁶ This view is shared by a large majority of the respondents to the public consultation on 'Science 2.0: Science in Transition' (2014): http://ec.europa.eu/research/consultations/science-2.0/consultation_en.htm

⁵⁷ *The Economist*, 'How Science goes wrong' *The Economist*, 19 October 2013: "Last year researchers at one biotech firm, Amgen, found they could reproduce just six of 53 'landmark' studies in cancer research. Earlier, a group at Bayer, a drug company, managed to repeat just a quarter of 67 similarly important papers. A leading computer scientist frets that three-quarters of papers in his subfield are bunk. In 2010 roughly 80,000 patients took part in clinical trials based on research that was later retracted because of mistakes or improprieties."

Research integrity, which can be defined as *“the performance of research to the highest standards of professionalism and rigour, in an ethically robust manner”*⁵⁸, is important to science because it creates trust, and trust is at the heart of the research process. Researchers must be able to trust and rely on each other’s work and *“they must also be trusted by society since they provide scientific expertise that may impact people’s lives”*. Thus, *“research integrity has the potential to increase the quality of research in the European research ecosystem, thereby increasing its overall effectiveness and impact into the future”*⁵⁹.

Research integrity, considered by the Commission as a prerequisite to scientific excellence, will support Open Science in particular by promoting behaviours leading to a better access to and sharing of available data. Research integrity can also build trust between science and wider society, optimise returns on investment and protect the EU and its interests. It therefore constitutes one of the priorities of European research policy.⁶⁰

The European Commission is developing a policy on research integrity comprising two main pillars:

1. Minimising breaches of research integrity in activities funded by Horizon 2020:

Horizon 2020 requires participants to meet the highest standards of research integrity, as set out, for instance, in the European Code of Conduct for Research Integrity⁶¹. Various elements safeguard adherence to these principles and enable the detection of research misconduct, including different tools to detect cases of misconduct during the evaluation process and the technical review of project proposals.

2. Increasing adherence to the highest standards of research integrity in the research and innovation system, in the EU and internationally

The Commission intends to increase awareness of the importance of actively seeking a high level of integrity, to make available a tool kit to support organizations in building or adapting their integrity system and to contribute to the availability of effective training material. It is also financing projects to identify the roots of research misconduct and suitable responses.⁶² Several actions have been launched to promote higher levels of research integrity in the EU and beyond, including cooperation with stakeholders to review the European Code on Research Integrity (ALLEA/ESF code); the creation of a European Research Integrity research community; promoting a research integrity culture through capacity building, awareness and skills; and efforts to increase reproducibility, exchange of best practices and international cooperation.

Making science more inclusive: Citizen Science

Open Science also aims to encourage the inclusion of non-institutional participants, in other words the general public, in the scientific process. Citizen science is *“scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions.”*⁶³ Initiatives like Galaxy Zoo and Zooniverse have shown that it is possible to get hundreds of thousands of people to help with scientific research. Zooniverse is produced, maintained and developed by the Citizen Science Alliance (CSA), whose member institutions work with many academic and other partners around the world to produce projects that use volunteers to help scientists and researchers deal with the flood of data that confronts them.

⁵⁸ Science Europe Briefing Paper, “Research Integrity: What it Means, Why it is Important and How we Might Protect it”, December 2015.

⁵⁹ *Idem*.

⁶⁰ This priority has been acknowledged by the European Council, which, on 1 December 2015 made several recommendations to the Commission, the Member States, the Scientific Community and other stakeholders: <http://data.consilium.europa.eu/doc/document/ST-14201-2015-INIT/en/pdf>

⁶¹ European Science Foundation (ESF) and All European Academies (ALLEA) 2011: The European Code of Conduct for Research Integrity: http://www.esf.org/fileadmin/Public_documents/Publications/Code_Conduct_ResearchIntegrity.pdf

⁶² See, for example, in the Horizon 2020 Work Programme 2014-2015, the calls GARRI.9.2015 – Estimating the costs of research misconduct and the socio-economic benefit of research integrity, and GARRI.10.2015- European Ethics and Research Integrity Network, and in H2020 Work Programme 2016-2017, the call SwafS-16-2016: Mapping the Ethics and Research Integrity Normative Framework.

⁶³ “Oxford English Dictionary List of New Words”. Oxford English Dictionary. Retrieved 13 September 2014.

On the one hand, citizen scientists improve the quality of data and scientific evidence. Purely at the level of 'collecting data', they often provide a data-source unknown to professional scientists, and they can often provide perspectives, experience or information that the professional scientists don't have.

On the other hand, Citizen Scientists often have a 'direct' interest at stake, be it in the faster development of medicines or to gain better insight in the quality of the local environments in which they live, to give but two examples. Citizen scientists are also collaborating globally to address societal challenges such as climate change or food security. Citizen Science can contribute to the Commission's goal of Responsible Research and Innovation, as it reinforces public engagement and can re-direct research agendas towards issues of concern to citizens.

This kind of citizen science is increasingly on the agenda and it is planned that future work programmes of Horizon 2020 will continue to support relevant initiatives at EU level. For instance, the continuation and upscaling of various citizens' observatories initiatives are foreseen, including an inducement prize for new products and services that will harness the data produced.

[illegible]

Citizens' Observatories – WeSenseIt

Europe's ability to mitigate and adapt to the effects of climate change is one of the challenges of our time. The number of people who will be affected by flooding is predicted to double over the next 70 years, with annual costs increasing from EUR 7.7bn to EUR 15bn. Traditional approaches to water cycle monitoring have two major drawbacks. First, the density and resolution of the collected data is still too low to describe the status of the water cycle (especially during anomalous events such as floods). Second, the communities affected play a passive role, usually at the end of the information chain.

The WeSenseIt project (2012-2016, www.wesenseit.eu/) is developing a citizen observatory of water that will allow citizens and communities to take on a new role in the information chain: a shift from traditional one-way communication towards a two-way model in which citizens become active stakeholders in capturing, evaluating and communicating information. This citizen observatory leverages environmental data and knowledge (from both professionals and communities) to manage water resources effectively and efficiently.

Citizens, such as volunteer flood wardens in the UK or civil protection volunteers in Italy, can help by taking measurements using new apps currently being developed by the project and sending information and images by phone. They can also help by reading existing sensors and sending authorities the data via mobile apps. New technologies and approaches to water management are being tested and validated in three EU countries: the UK, the Netherlands and Italy.

WeSenseIt also has a strong focus on creating new economic opportunities. One company within the Consortium is already commercialising a tool developed in 2013, just ten months into the project. The tool, which carries out large scale social media analysis to help emergency responders during large scale floods, found an application in monitoring large city-wide events in the UK. Events involving over 600 000 citizens were monitored with excellent results, reflecting the scope of potential applications of this kind.

4. CONCLUSIONS

The research process of the future will be global, networked and open. Many more actors will take part in different ways and the traditional methods of organising and rewarding research will also see many changes. The essence of the science process – peer review, discovering new frontiers – will not change, but the way it is done will certainly be different.

Achieving the following objectives in the coming years will enable European science to meet the challenges and opportunities of the networked knowledge society, and create the kind of Open Science environment described at the beginning of this chapter.

FAIR data sharing should be the default for funding scientific research and all European researchers should be able to deposit, access and analyse European scientific data through the European Open Science Cloud.

Peer reviewed scientific publications should be freely accessible. The evaluation of research careers should fully acknowledge Open Science activities and funders and stakeholders should have come to agreement on how alternative metrics can complement or replace the current system. All young scientists in Europe should have the necessary skills and support to be Open Scientists and all publicly-funded research in the EU adheres to commonly agreed Open Science standards of research integrity. A truly Open Science will also see citizen scientists making a significant contribution as valid producers of knowledge. Open Science will be a better science, which will be better able to meet the many societal and economic challenges that we face in the 21st century.



Open
to the World

OPEN TO THE WORLD

Fostering international cooperation in research and innovation is a strategic priority for the European Union so that we can access the latest knowledge and the best talent worldwide, tackle global societal challenges more effectively, create business opportunities in new and emerging markets, and use science diplomacy as an influential instrument of external policy.

The European Commission is active on several fronts to help ensure that European research and innovation are 'Open to the World'. It is leading several global initiatives and working with international organisations; it is helping develop the framework conditions that underpin international cooperation; and it is maximising synergies with the EU's external policies and the activities of Member States. It has opened up

Horizon 2020 to researchers and innovators from across the world and it holds regular dialogues with key international partner countries and regions on science and technology cooperation.

These efforts have very practical aims in mind. Being 'Open to the World' means striving to ensure that EU research and innovation can work at a global level for all of us. Whether mobilising EU funding for a rapid and effective global research response to outbreaks like Ebola or Zika; contributing to the evidence base for the International Panel on Climate Change and COP21 negotiations as over a thousand results from EU-funded research projects have done; benchmarking innovative European solutions for green urban mobility in Latin America, or promoting scientific cooperation in the Middle East through the SESAME project.

"We need to be Open to the World! Europe is a global leader in science, and this should translate into a leading voice in global debates. To remain relevant and competitive, we need to engage more in science diplomacy and global scientific collaboration. It is not sufficient to only support collaborative projects; we need to enable partnerships between regions and countries.

Challenges in areas like energy, health, food and water are global challenges. And Europe should be leading the way in developing global research partnerships to address these challenges. This means speaking with one voice, and close coordination with Member States' international collaborations.

But I would like to go much further and begin building a global research area. This will not happen in one step, but through developing partnerships with other areas."

*Commissioner Carlos Moedas,
"A new start for Europe: Opening up to an ERA of Innovation", Brussels, 22 June 2015*

1. THE CONCEPT IN EVOLUTION: THE INCREASING IMPORTANCE OF INTERNATIONAL COOPERATION

While the globalisation of research and innovation is not a new phenomenon, it has become increasingly visible, particularly in terms of collaborative research, international technology production, and the worldwide mobility of researchers and circulation of knowledge.

The increased interaction between science and technology actors at world level is partly due to the emergence of new international players with large research and innovation capacities, but also to a stronger political focus on addressing global challenges.

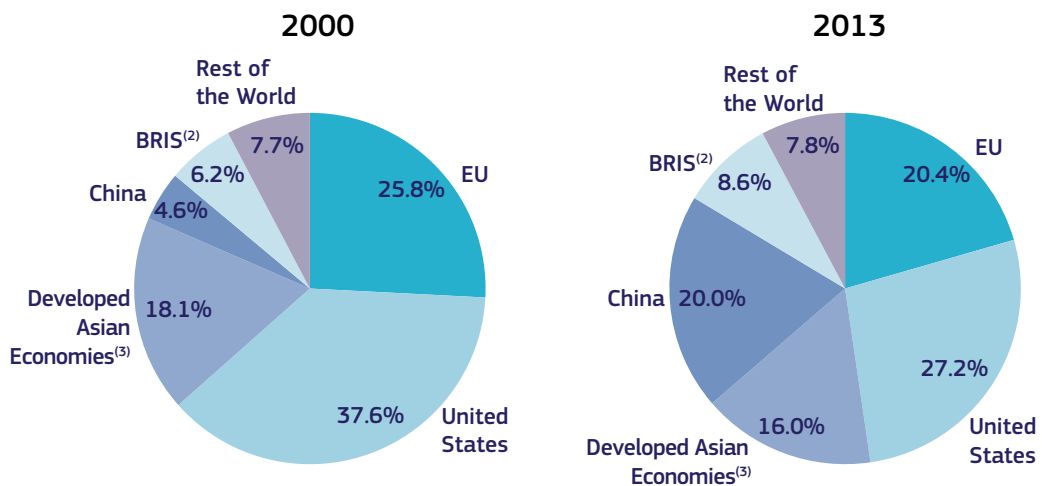
As more research and innovation is performed outside Europe, the EU will need to access this knowledge. And to remain a major global player, the EU must promote itself as an attractive location for carrying out research and innovation and be successful in the global competition for talent, while at the same time preserving its economic interests, notably as regards intellectual property rights and standards.

Global challenges are important drivers for research and innovation. Our planet has finite resources which need to be cared for sustainably; climate change and infectious diseases do not stop at national borders, and food security needs to be ensured across the globe. The Union needs to strengthen its dialogues with international partners to build critical mass for tackling these challenges.

The world is becoming both more R&D-intensive and multipolar, and the relative weight of the EU in this new global R&D landscape is falling. While the EU and United States together represented nearly two-thirds of global R&D expenditure in 2000, this share had shrunk to less than half by 2013.

The EU and US shares of world expenditure on R&D fell from 25.8% to 20.4% and from 37.6% to 27.2% respectively, which is mainly due to the rapid rise of China, which more than quadrupled its share between 2000 and 2013, from 4.6% to 20.0%. Figure OW.1 shows the trend in the distribution of world GERD (Gross Domestic Expenditure on R&D).

Figure OW.1: % distribution of world GERD⁽¹⁾, 2000 and 2013



Source: Science, research and innovation performance of the EU 2016 - A contribution to the open innovation, open science, open to the world agenda, European Commission 2016, ISBN: 978-92-79-49557-1

Data: Eurostat, OECD, UNESCO

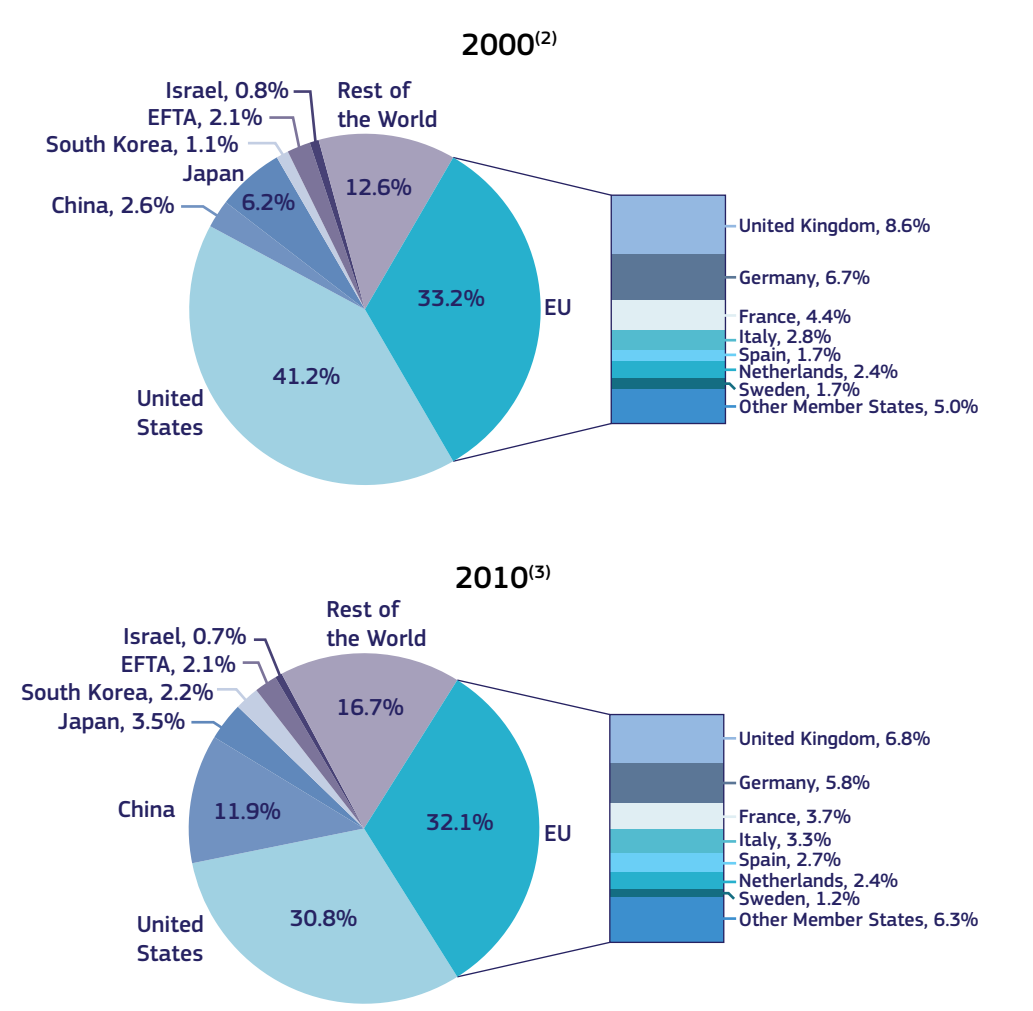
Notes: ⁽¹⁾The % shares were calculated from estimated values in current PPSE. ⁽²⁾BR+RU+IN+ZA. ⁽³⁾JP+KR+SG+TW.

As a result of increasing R&D investments, a growing number of international partners have been expanding their scientific production. In the last decade, the geographical distribution of knowledge production has changed significantly: while Europe remains the world's leading producer of scientific knowledge, ahead of the US, some emerging countries have also become major producers of knowledge. For example, China increased its share of world scientific publications from 6% to 19.5% between 2000 and 2013, overtaking the

United States (19.1%) as second biggest knowledge producer in the world, with the EU share at 27.3%.

In this changing and challenging landscape, Europe has been able to maintain its lead in terms of highly cited scientific publications (see Figure OW.2), implying that it has continued to produce the very best science even when other parts of the world have increased their R&D investments much more.

Figure OW.2: World share of highly cited scientific publications⁽¹⁾, 2000 and 2010



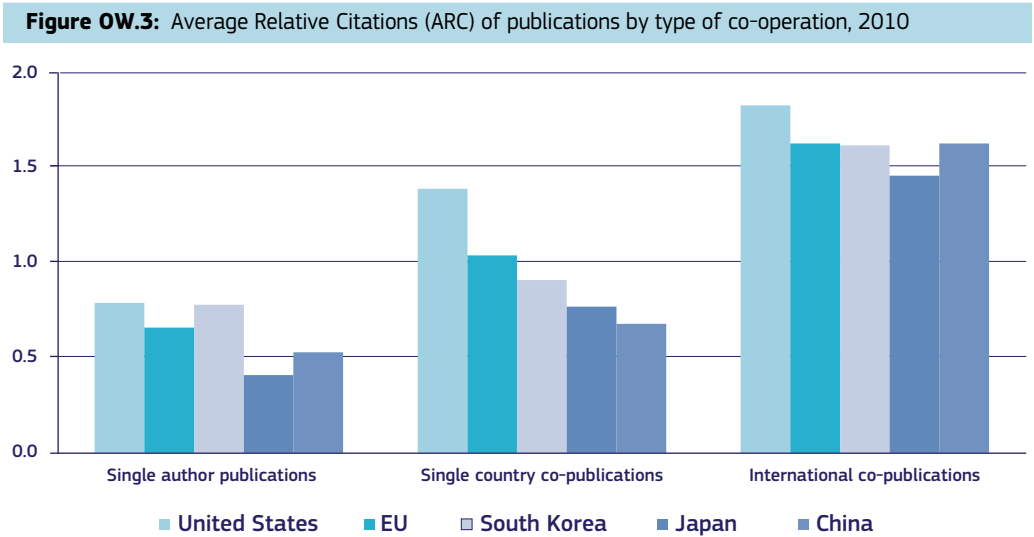
Source: Science, research and innovation performance of the EU 2016

Data: Science-Metrix (Canada), based on Scopus database

Notes: ⁽¹⁾Fractional counting method. ⁽²⁾Scientific publications 2000, with citation window 2000-2003. ⁽³⁾Scientific publications 2010, with citation window 2010-2013.

Evidence shows that stronger international collaborations have a clear positive impact on the overall performance of national research and innovation systems. The Average Relative Citations (ARC) of publications (see Figure OW.3) is an indicator of the scientific impact of papers produced by a given entity (in this case, a country) relative to the world average. An ARC value above 1 means that a given entity is cited more frequently than the world average, while a value below 1 means the opposite.

For all research and innovation key players, the ARC of international co-publications is much higher than that of single country co-publications or single author publications. Furthermore, only the ARC of international co-publications scores above 1 in all countries and regions. This means that, overall, international co-publications have a higher scientific impact than the world average.

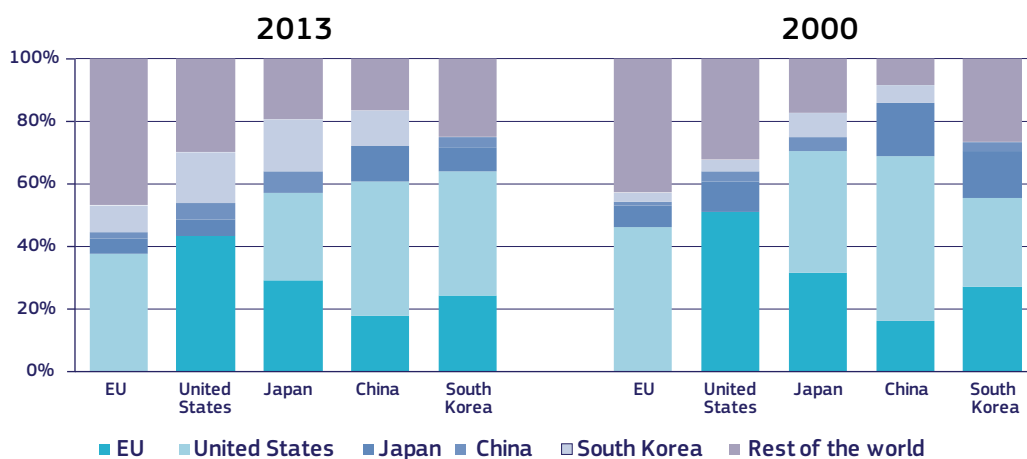


Source: Science, research and innovation performance of the EU 2016
Data: Science-Metrix (Canada), based on Scopus database

The United States remains the EU's main partner in scientific collaboration, as shown by the number of international co-publications (see Figure OW.4). EU-China scientific collaborations have increased significantly, but not as much as for US-China.

South Korea and China tend to collaborate more with the US than with the EU. This seems to suggest that the United States has been able to take greater advantage of the emerging research capacities of Asian economies than the EU has.

Figure OW.4: International scientific collaborations, 2000 and 2013



Source: Science, research and innovation performance of the EU 2016

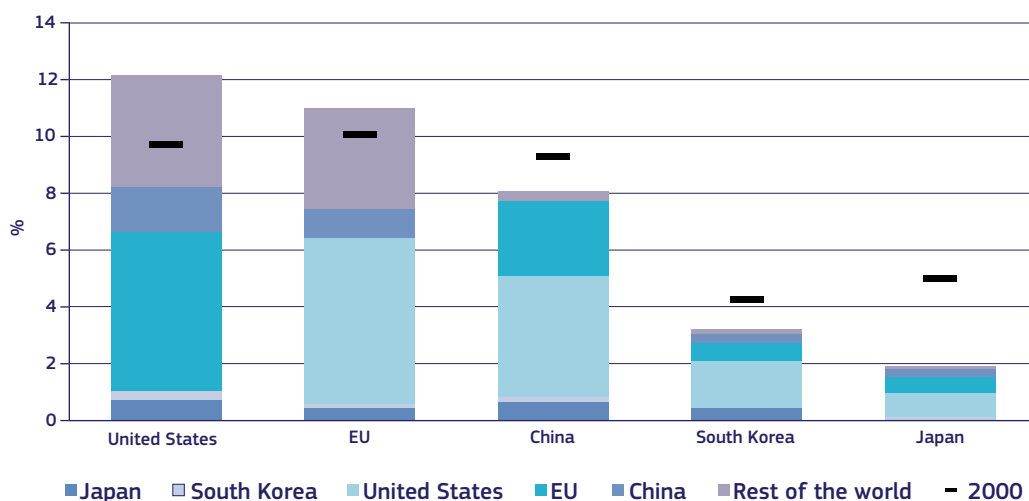
Data: DG Research and Innovation, based on Scopus database

Note: Elements of estimation were involved in the compilation of the data.

Despite the increasing internationalisation of technological collaborations, compared to the United States, Europe is not taking full advantage of international networks. International technological collaborations play a key role in the innovation process by allowing firms to access a broader set of competences, resources and skills. Patents with foreign co-inventors may be used as a measure of the internationalisation of the

research and innovation system and of the exchange of knowledge between research and innovation actors (see Figure OW.5). Technological collaboration at international level has intensified in the last decade both in the United States and the EU. The US has overtaken the EU in terms of share of patents resulting from international collaborations and the gap between the two countries seems to be increasing.

Figure OW.5: Share (%) of patents with foreign co-inventor(s) in total patent applications (WIPO PCT), 2000 and 2012



Source: Science, research and innovation performance of the EU 2016

Data: OECD

Countries such as China, South Korea and Japan rely relatively more on their own research and innovation systems than on international co-inventions, although in absolute terms the number of international co-inventions has significantly increased from 2000 to 2012 (China from 140 to 1,598 ; South Korea from 86 to 365; Japan from 552 to 844).

Open to the World: the EU strategy for global Research and Innovation cooperation and science diplomacy

The strategy⁶⁴ for EU international cooperation in research and innovation, published in September 2012 and welcomed by the European Council and European Parliament, aims to strengthen the EU's research and innovation excellence and attractiveness and its economic and industrial competitiveness, to tackle global societal challenges, and to support its external policies.

The strategy is driven by the importance of cooperating internationally to give Europe access to the best talent, knowledge and resources wherever they are located; to tackle global societal challenges in the most effective way in a partnership approach; to help establish new opportunities for European high-tech industries through participation in global value chains and access to new and emerging markets; and to have a leading voice in global debates and developments.

To increase the effectiveness of international cooperation, while avoiding a wasteful fragmentation

of efforts, the Commission prioritises actions of critical mass in terms of scale/resources and scope/coverage. Priority areas for international engagement are identified on the basis of the following criteria:

1. Research and innovation capacity
2. Access to markets and their impact on EU competitiveness
3. Contribution to the EU's international commitments
4. Legal and administrative frameworks in place to engage in cooperation.

All available instruments are put to use to maximise the impact of international cooperation on research and innovation. Horizon 2020 is the main vehicle, fully open to participants from across the world and with many topics specifically targeting international cooperation. Cooperation takes place in research and innovation projects, networking between projects, joint or coordinated calls, and specific joint initiatives.

Increasingly, non-funding instruments are being used to support the objectives of the strategy. These include, in particular, cooperation with Member States and Associated Countries through the Strategic Forum for International Science and Technology Cooperation (SFIC) as well as policy dialogues on S&T cooperation with key international partner countries, regions and organisations. This approach also involves the use of science, research and innovation cooperation to support the objectives of other EU policies, in particular external policies where science diplomacy can be used to build bridges between people and nations and encourage peaceful relations.

"I believe science diplomacy is the torch that can light the way, where other kinds of politics and diplomacy have failed. A torch to illuminate how we can progress in science and innovation side by side. The torch that brightens a doorway to cooperation and communication that is never closed.

I want science diplomacy to play a leading role in our global outreach for its uniting power. Certainly with our closest partners, but, even more so, where it can make an even greater difference: where the political situation is more complex."

*Commissioner Carlos Moedas,
"The EU approach to science diplomacy", Washington, 1 June 2015*

⁶⁴ COM(2012) 497: Enhancing and focusing EU international cooperation in research and innovation: A strategic approach, http://ec.europa.eu/research/iscp/pdf/policy/com_2012_497_communication_from_commission_to_inst_en.pdf#view=fit&pagemode=none



2. THE LINK TO OPEN INNOVATION AND OPEN SCIENCE

To maximise their potential, the main components of the ‘Open Innovation’ and ‘Open Science’ policies should also be ‘Open to the World’.

For instance, EU policy initiatives such as Horizon 2020 or the European Fund for Strategic Investments (EFSI) should also attract international partners to invest in research and innovation in Europe; initiatives should also be open to partnering with entities outside Europe.

Open Science is making strides across the world and will be able to fulfil its greatest potential if we cooperate with partners on issues such as open access and data.

International collaboration plays an increasingly important role both in improving the competitiveness of research and innovation systems and in fostering new knowledge production worldwide. See also the

section “Thematic cooperation targeting new value chains and growing markets”, below.

Furthermore, the increasing number, scope and complexity of global challenges require more than ever international collaboration across disciplines and sectors to tackle challenges such as climate change, resource scarcity, or infectious diseases.

For example, the European Commission took the initiative to set up the Global Research Collaboration for Infectious Disease Preparedness (GloPID-R)⁶⁵ that brings together funding organisations on a global scale for an effective research response to major outbreaks of infectious diseases with pandemic potential. It has proven its value in the Ebola outbreak⁶⁶ as well as the Zika outbreak⁶⁷, being able to mobilise a global research response with effective collaboration rather than competition or duplication.

⁶⁵ <http://www.glopid-r.org/>

⁶⁶ <https://ec.europa.eu/research/health/index.cfm?pg=area&areaname=ebola>

⁶⁷ <https://ec.europa.eu/research/health/index.cfm?pg=area&areaname=zika>

3. OPEN TO THE WORLD IN THE COMMISSION'S NEW PRIORITIES

Leading multilateral initiatives and working with international organisations to tackle global societal challenges

Very often international cooperation to tackle societal challenges in areas like health, food, energy and water is best implemented through global multilateral initiatives where solutions can be developed and deployed more effectively.

The Commission is leading the way in many global research partnerships to tackle societal challenges. The results of EU research and innovation contribute to the development and implementation of important international commitments such as the UN Convention for Climate Change, the Convention on Biological Diversity, the 2030 Agenda for Sustainable Development, and Resolutions of the World Health Organisation.

For instance, one important milestone in the development of international climate policy was the adoption of the International Panel on Climate Change (IPCC) 5th Assessment Report that provided the evidence base for the COP21 negotiations. More than one thousand highly relevant publications from projects funded by the EU's Framework Programme for Research were assessed in this Report⁶⁸, with particularly relevant contributions in areas such as sea-level rise, ocean acidification and in the assessment of possible mitigation pathways. Another example is the UN-Habitat programme⁶⁹ promoting socially and environmentally sustainable cities with science, technology and innovation as a central means of implementation and a clear recognition of the importance of international cooperation in research and innovation to foster sustainable urbanisation.

A significant proportion of knowledge deriving from medical and health research often does not reach the patients in question, and successful treatments are sometimes not widely provided. These are the consequences of poor understanding of the

complexity of implementation and the context in which the intervention is proposed, as well as a poor involvement of the people who are responsible for the delivery of care. In this context, the Global Alliance for Chronic Diseases (GACD)⁷⁰ focuses on applying the best healthcare interventions, targeted to different populations, geographical settings and socioeconomic contexts. It therefore fills the huge gap between providing the evidence base for policy and the actual implementation of the policy in real world settings. The ten international funders that participate in the GACD support collaborative research among low- and middle-income and high-income countries on low cost interventions to build capacity in research and health care delivery to fight chronic diseases, and foster a sustainable and significant reduction in illness, disability, and death around the world.

The International Rare Diseases Research Consortium (IRDIRC)⁷¹ brings together funding agencies and researchers from across the world to increase investments in research on rare diseases. This is an excellent example of how it is necessary to join forces internationally to tackle a problem that unfortunately does not reach a critical mass in a single (national) research system. 35 funding bodies from 40 countries are sponsoring research projects with the overall aim of delivering 200 new therapies for rare diseases and the means to diagnose most rare diseases by 2020.

Tracking climate and environmental change worldwide requires timely and accurate Earth observation data, which in turn requires appropriate policies and infrastructure to gather and manage the information. The Group on Earth Observations (GEO), which implements the Global Earth Observation System of Systems (GEOSS) and the Belmont Forum with its Collaborative Research Action on 'E-infrastructure and data management' are both supporting common data management principles, including open and full access to data, to be implemented worldwide through joint collaborative actions.

⁶⁸ IPCC (2013 and 2014), 5th Assessment Report: <https://www.ipcc.ch/report/ar5/>

⁶⁹ <http://unhabitat.org/>

⁷⁰ <http://www.gacd.org/>

⁷¹ <http://www.irdirc.org/>

The Belmont Forum aims to deliver the knowledge needed to avoid and adapt to detrimental environmental change. It is composed of some 20 funding agencies from industrialised and emerging countries, co-chaired by the Commission and the Sao Paulo Research Foundation (FAPESP). The Forum expedites the delivery of the environmental research needed to remove critical barriers to sustainability by aligning and mobilising international resources. Collaborative research actions following joint calls have included Freshwater Security, Food Safety and Security, and Blue Growth. In 2016 two new actions are planned on Food, Water and Energy for Sustainable Global Urbanisation and on Transformations to Sustainability. As a member of the Science and Technology Alliance for Global Sustainability, the Forum also co-designed the Future Earth initiative to create a global, independent platform for scientific collaboration on global change research and sustainability, integrating and replacing currently disparate international programmes.

The Group on Earth Observations (GEO), is a voluntary partnership of 102 governments and

92 participating organisations. Together, the GEO community is creating a Global Earth Observation System of Systems (GEOSS) that will link Earth observation resources world-wide across different areas – including Biodiversity and Ecosystem Sustainability, Disaster Resilience and Water Resources Management – and put those resources at the service of better informed decision-making for citizens and for business. The new GEO mandate (2016-2025) brings new opportunities to reinforce the EU's international standing and diplomatic influence on the global sustainability agenda and to stimulate growth and jobs in Europe in the context of the digital economy.

The Transatlantic Ocean Research Alliance is another good example of a recent initiative to pool research knowledge on an international issue. Its goal is to work together across the Atlantic in order to better understand and predict major ocean and interlinked Arctic processes and to promote the sustainable management of resources. The Alliance is based on the Galway Statement⁷² signed in 2013 by the EU, its Member States, the US and Canada.

“We need to build and invest in a blue economy that both protects and harvests our oceans’ abundance. So that this generation may prosper and future generations still reap the benefits. Together, we can achieve this by improving our ocean observation and forecasting capacity, by increasing our understanding of ocean dynamics. All the while, disseminating knowledge of this valuable resource to citizens.”

*Commissioner Carlos Moedas
“The Atlantic – Our Shared Vision, European Parliament”, Brussels, 16 April 2015*

A more recent example is the global ‘Mission Innovation’ initiative that aims to reinforce public and private investment in clean energy innovation, to develop and deploy breakthrough technologies and to make clean energy widely affordable. It gathers 20 countries seeking to double the financing for clean energy research. The EU wishes to join this initiative, given that it has already doubled its allocation

to low carbon related energy research from the Seventh Framework Programme to Horizon 2020 and that it has committed to invest at least 35% of Horizon 2020 in climate-related activities.

Another example is in fusion energy research, where international cooperation has taken place for many years. This is culminating in the construction of ITER⁷³

⁷² https://ec.europa.eu/research/iscp/pdf/galway_statement_atlantic_ocean_cooperation.pdf

¹⁰ www.iter.org

in France that, when completed, will demonstrate the viability of fusion as an energy source. Europe also hosts the world's largest operational fusion device, the Joint European Torus (JET). JET has been an international centre for fusion energy research for decades and highlights how EU fusion research is and continues to be open to the world.

Further action should enhance the role of the EU in global multilateral fora and international organisations. A stronger and more coherent EU strategy vis-à-vis the activities of such fora and organisations should give the EU a leading voice to push for larger global investments in innovative solutions to the global societal challenges that are at the top of the EU's priorities list.

Improving the framework conditions for engaging in international cooperation

Science and innovation are global endeavours and researchers should be able to work together smoothly across borders, particularly on large-scale common challenges. The strategic approach to EU international cooperation aims to develop common principles and adequate framework conditions for engaging in cooperation.

The European Commission is proactive in addressing obstacles to the efficient international cooperation of researchers and innovators by ensuring fair and equitable framework conditions such as reciprocal access to programmes, mechanisms for co-funding, mutual access to resources, and efficient and fair intellectual property rights systems.

A particular focus of political dialogues under international science and technology (S&T) agreements is to stimulate and assist partner countries to set up co-funding mechanisms for their participants in Horizon 2020 actions. So far, such arrangements exist in several partner countries including South Korea, Mexico, China, Russia, Japan, Australia, regions of Brazil, and the province of Quebec, Canada.

A Global Research Area

One focus has been on the concept of a Global Research Area where researchers and innovators are able to work together smoothly with colleagues worldwide and where researchers, scientific knowledge and technology circulate as freely as possible.

The external dimension of the European Research Area is serving as an example and benchmark towards more coherent and efficient collaboration in research and innovation at global level. In this way Europe is reinforcing its position as a global research powerhouse, to attract and retain the best researchers, boost competitiveness, support market uptake through confidence building, and encourage future cooperation with global research partners.

The building of a Global Research Area is proceeding step-by-step with different priorities and actions that vary from one region to another, based on the EU's specific objectives for each region or group of countries in question.

Case-study: EU-CELAC

The EU-CELAC (Community of Latin America and Caribbean States) Common Research Area was declared a common objective at the June 2015 Summit between the two regions, to improve the level and intensity of cooperation in research and innovation. The Common Research Area will be based on three pillars: increased mobility of researchers; improved access to research infrastructures and data; and jointly addressing common challenges such as environment and climate change, sustainable urbanisation, bio-economy, health and ICT.

Case-study: PRIMA

Another example is cooperation in the Mediterranean region on how to ensure the sustainable provision of vital resources such as water and food. PRIMA, the Partnership for Research and Innovation in the Mediterranean Area, involves several countries and their research communities on both sides of the Mediterranean. Rapid demographic, socio-economic,

and climate changes are threatening the sustainable development of the Mediterranean region, especially the capacity of its agriculture to cope with increased demand for food production in a scenario of water scarcity and increasing competition for water use between different sectors. To address this challenge, EU and non-EU countries are engaging in a significant and well-coordinated research effort at regional scale to develop and deploy innovative solutions for sustainable food production and water use.

Case study: China

The October 2015 Joint Committee on EU-China Science and Technology cooperation addressed progress in the priority areas of food, agriculture and biotechnology, sustainable urbanisation including energy; transport,

environment and ICT; aviation; fusion and fission, and space technology and Earth observation. The Committee also addressed the framework conditions for cooperation and underlined its commitment to the EU-China Innovation Cooperation Dialogue, which in June 2015 discussed respective innovation policies and agreed to ensure reciprocal access to respective research and innovation funding programmes through participation rules based on equal treatment, timely and clear information to participants and regular exchange of data. Agreement was also reached on setting up a new co-funding mechanism to support mainland China-based research and innovation organisations participating in joint EU-China projects under Horizon 2020. The budget ceiling of the mechanism is 200 million RMB or 28 million euro per year.

“First, we should boost our investment in research and innovation cooperation between our regions. Horizon 2020 is open to international cooperation. We have invested a lot in collaborative research projects involving Chinese participants so far. A co-funding mechanism to boost EU-China cooperation in research and innovation has been agreed with the Chinese Ministry of Science and Technology. Second, we should create better regulatory conditions to allow our researchers and companies to innovate and to cooperate across borders. Third, with the increasing role that scientific evidence will play in the European policy making process, dialogue with China could develop complementary approaches to face global societal challenges with science policy. Fourth, ongoing cooperation in the area of large research infrastructures is of increasing importance globally. The EU and China are already cooperating in very ambitious infrastructures programmes, such as the International Thermonuclear Experimental Reactor (ITER), but there remains plenty of scope for further cooperation on both continents.”

Commissioner Carlos Moedas, “Promoting excellence through enhanced EU-China researcher mobility and cooperation”, Beijing, 7 September 2015

Further action should continue to build a Global Research Area, proceeding area-by-area to shape partnerships with Member States, Associated

Countries and international partner countries, regions and organisations.

Research and innovation as an agent of integration of neighbouring countries

The focus of the European Union's cooperation with its neighbours on research and innovation is to foster integration into, or alignment with, the European Research Area, including through their possible association to Horizon 2020. This is contributing to developing a 'Common Knowledge and Innovation Space', that includes helping to improve the research and innovation competences of these countries⁷⁴.

Cooperation occurs in close coordination with the instruments of the enlargement and neighbourhood policies that help to build up research capacity. Research and innovation funding focuses on finding innovative solutions to the challenges faced by the EU's neighbours (see Figure OW.6).

Efforts are also being made in the context of the Horizon 2020 Policy Support Facility (PSF) that provides Member States and countries associated to the programme with practical support to design, implement and evaluate reforms that enhance the

quality of their research and innovation investments, policies and systems. On request from national authorities, the PSF offers a broad range of expertise and services including peer reviews of national research and innovation systems. Peer reviews of Moldova and Ukraine will be concluded in 2016, leading to concrete recommendations to the national authorities on the reforms needed to strengthen their research and innovation systems.

Another example of cooperation with the EU's neighbours is EaPConnect⁷⁵ which will provide Eastern Partnership countries (Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine) with huge broadband capacity dedicated to scientific research. This will be achieved by improving the current interconnections with the European GEANT network, the most powerful for research and education worldwide. The objective will be to provide broadband Wi-Fi access on university campuses, and access to a wide range of scientific publications and databases, helping integrate the Eastern partnership countries into the EU and international scientific communities.

"It is a great honour to have signed Ukraine's Association Agreement to Horizon 2020 this morning. The first time that Ukraine has been associated to an EU programme. A historic day. A remarkable achievement. I warmly welcome the further integration of Ukraine into the European Research Area.

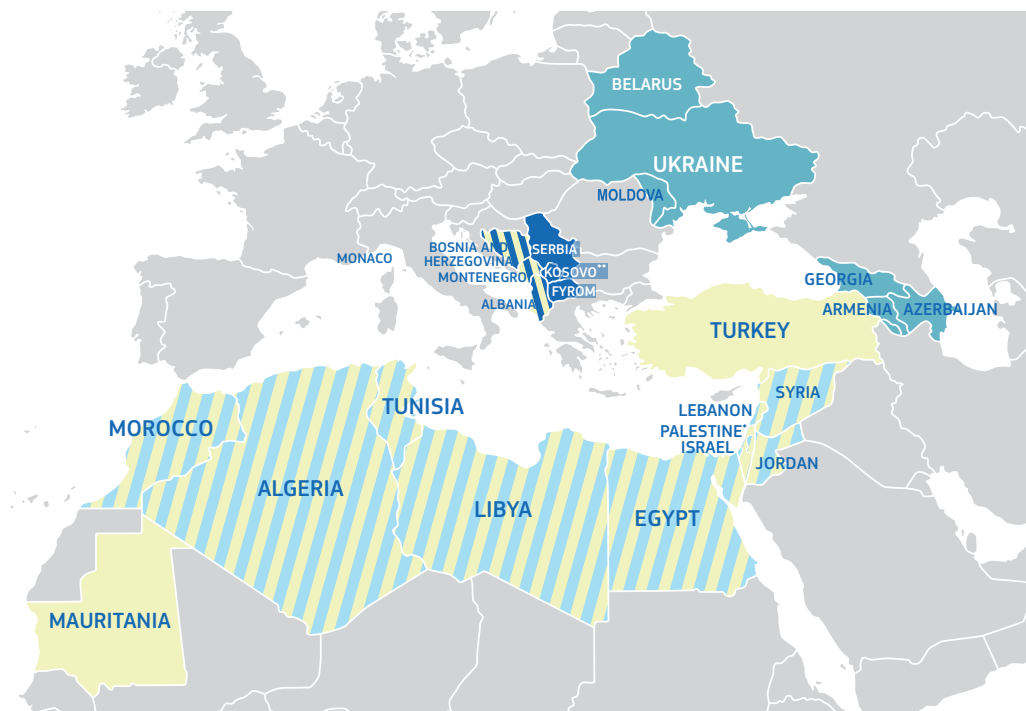
The list of benefits of today's association agreement to Ukraine and to the European Union is both long and significant. It will now be possible for Ukraine to host European Research Council grants. It will now be possible to share research infrastructure. Ukrainian researchers will be eligible to apply for all mobility schemes and fellowships of the Marie Skłodowska-Curie Actions. Ukrainian businesses will now have access to the Horizon 2020 instrument for Small and Medium-sized Enterprises. The list goes on. And the EU is excited to learn from you and to engage with you. We look forward to strengthening our cooperation and growing together."

*Commissioner Carlos Moedas
Ukraine Association Agreement to Horizon 2020, Kyiv, 20 March 2015*

⁷⁴ The European Neighbourhood Policy governs the EU's relations with 16 of the EU's closest Eastern and Southern Neighbours. To the South: Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria and Tunisia and to the East: Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine. Of these, Israel, Moldova and Ukraine are associated to Horizon 2020 and Tunisia, Georgia and Armenia are in the process of finalising association agreements (situation as of 4 February 2016)

⁷⁵ <https://www.eapconnect.eu/>

Figure OW.6: Cooperation with countries in the Eastern Partnership, Western Balkans, Southern Neighbourhood and Mediterranean



* This designation shall not be construed as recognition of a State of Palestine and is without prejudice to the individual positions of the Member States on this issue.

**This designation is without prejudice to position on status, and is in line with UN Security Council Resolution 1244/99 and the International Court of Justice Opinion on the Kosovo declaration of independence.

- Bi-regional dialogues between the EU and: Eastern Partnership** (Belarus, Armenia, Azerbaijan, Georgia, Moldova, Ukraine)
- Western Balkan Platform** (Albania, Bosnia and Herzegovina, the former Yugoslav Republic of Macedonia, Montenegro, Serbia, Kosovo)
- Southern Neighbourhood** (Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria, Tunisia)
- Union for the Mediterranean** (Albania, Algeria, Bosnia and Herzegovina, Egypt, Israel, Jordan, Lebanon, Mauritania, Monaco, Montenegro, Morocco, Palestine, Syria, Tunisia and Turkey)

Strengthening synergies with the EU's external policies

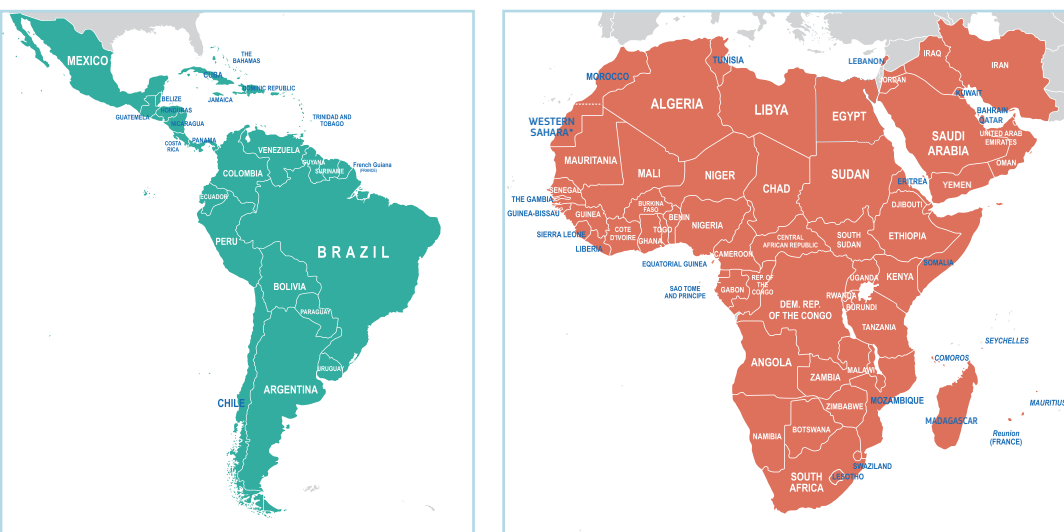
The challenges that Europe faces today have increasingly interlinked external and internal dimensions – migration, radicalisation and energy security being cases in point. The urgency of these challenges requires swift political decisions and joint international responses.

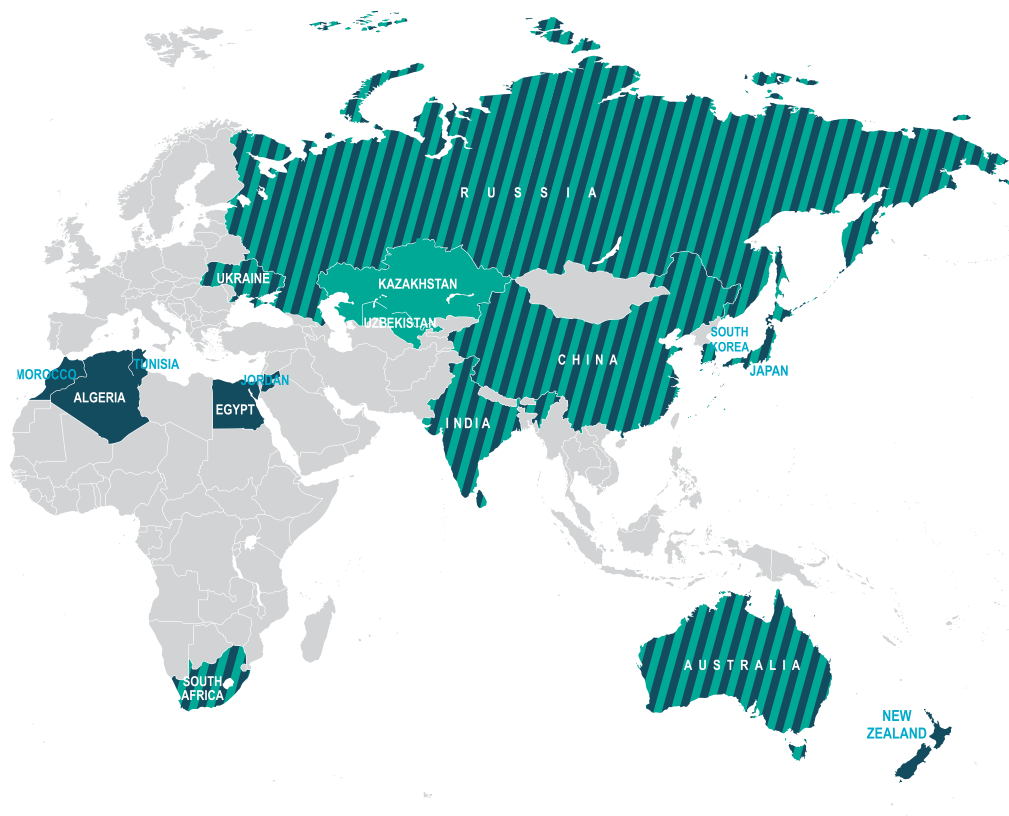
Science and technology cooperation is very often an important element in deepening relations with key partners of the EU. The European Commission holds regular science and technology cooperation dialogues with some 20 key international partner countries, as well as high level policy dialogues with the main world regions. These dialogues cover thematic research and innovation cooperation as well as actions to ensure favourable and equitable conditions for the efficient cooperation of researchers and innovators (see Figures OW.7 and OW.8).

Figure OW.7: Scientific and Technologic Cooperation Agreements between the EU / Euratom and the rest of the world



Figure OW.8: Cooperation with Latin America and Caribbean, Africa, Middle East and South-East Asia





 **CELAC-Community of Latin American and Caribbean States** (33 states, <http://www.celacinternational.org/>)

 **African Union** (54 states, <http://www.au.int/en/countryprofiles>)

Gulf Cooperation Council (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates)

MENA-Middle East and North Africa (ad hoc; Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, United Arab Emirates, Yemen)

 **ASEAN-Association of South-East Asian Nations** (Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei, Vietnam, Laos, Myanmar, Cambodia)

*The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance.

As regards science and technology cooperation with developing countries, the emphasis is on building partnerships, in particular bi-regional partnerships, to contribute to the sustainable development of these regions and address challenges such as climate change, sustainable agriculture, food security and health.

The effective soft power tool of science diplomacy is being used more and more to support external policy objectives for peace, security, humanitarian aid, and social and economic development. Science diplomacy is the use of science to prevent conflicts and crises, underpin policy making, and improve international relations in conflict areas where the universal language of science can open new channels of communication and build trust. Scientific evidence and advice are increasingly indispensable for anticipating needs and events and for making informed, forward-looking foreign policy decisions.

Science and scientific values of rationality, transparency and universality can provide a common language and common basis for engagement and trust, even so far as building better relationships between potential parties to a conflict. Science diplomacy may take several forms, for example direct diplomatic efforts by scientists as in the 2015 nuclear deal with Iran⁷⁶; scientific advice to diplomats (e.g. game theory, cognitive psychology) on negotiating positions and approaches that are likely to be successful; or research collaborations between scientific communities in the various countries involved that are likely to increase mutual understanding and trust, indirectly strengthening civil society and evidence-based policy-making and influencing politicians to follow in the same direction.

Case-study: SESAME

The Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME) is an international project launched in 2003 under the auspices of UNESCO with the aim of using science diplomacy to foster a culture of peace and cooperation in the broader Middle East. It is expected to be operational by 2017. SESAME's partners include Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestine and Turkey, with the EU, France, Germany, Greece, Italy, Portugal, Spain, Sweden, UK,

Brazil, China, Japan, Kuwait, Switzerland, Russia and the US as observers.

The project is building a research infrastructure, fostering science and technology excellence in the region and tackling the scientific brain drain through world-class research in subjects ranging from biology, archaeology and medicine, to materials science, physics, chemistry, and life sciences. At the same time, it is building scientific and cultural bridges between different countries. Already more than 350 scientists from the region have used SESAME's facilities, even before its completion.

SESAME is modelled on CERN, one of the pioneers in Europe of using science as a way of fostering a culture of dialogue and cooperation. The project is based on expertise, technical assistance and equipment made available by European partner laboratories. The EU's key technical contribution is the state-of-the-art magnet system for the main storage ring of SESAME, which is considered the catalyst for the realisation of the project. The EU has foreseen further support to enhance SESAME's training capacities.

Case-studies: Science diplomacy across the globe

Another example of international science diplomacy is cooperation in the Arctic. Here, EU-driven international scientific cooperation and research and innovation dialogues often precede political negotiations on complex issues, ranging from the impacts of climate change to new transport routes. Cooperation in scientific research is also a key element of the diplomatic effort towards obtaining EU observer status at the Arctic Council⁷⁷.

The BONUS initiative⁷⁸ can also be viewed through the angle of science diplomacy. This initiative strives for an economically and ecologically prosperous Baltic Sea region, where resources and goods are used sustainably and where the long-term management of the region is based on sound knowledge.

⁷⁶ Joint Comprehensive Plan of Action on Iran's nuclear programme, 14 July 2015

⁷⁷ <http://www.arctic-council.org/>

⁷⁸ <http://www.bonusportal.org/>

Another example is the European and Developing Countries Clinical Trials Partnership (EDCTP2)⁷⁹ that aims to accelerate the development of new or improved drugs, vaccines, microbicides and diagnostics against poverty-related and neglected infectious diseases in sub-Saharan Africa. EDCTP2 demonstrates the opportunities that science, research and innovation offer to bridge political borders and cultural differences, with knowledge, expertise and know-how flowing between countries.

Research and innovation are also an important tool in dealing with disasters – from preventing and detecting emerging threats, to assessing our vulnerabilities, to enhancing resilience and recovery. For example, the innovative system developed by the EU REAKT project monitors sudden increases in traffic on the European Mediterranean Seismological Centre which allows the origin and location of earthquake activity to be identified within just two minutes. Combined with data from online public behaviour, this enables the system to swiftly map out areas where tremors have been felt, where potential damage may occur, and where relief may be needed.

In the future, science diplomacy should be used more broadly as an influential instrument of the EU's external policy. International research and innovation cooperation leading to common standards, scientific exchange and mobility, the sharing of resources and facilities, and scientific advice to diplomats and diplomat scientists should help underpin good governance and policy-making and build mutual understanding and trust. As such, science diplomacy should become an element of the renewed Global Strategy on the EU's Common Foreign and Security Policy⁸⁰.

Greater synergies with the actions of Member States

The European Commission and the Member States have made considerable progress in deepening their partnership on enhancing and focussing international cooperation actions, particularly in the context of the Strategic Forum for International Science and Technology Cooperation (SFIC)⁸¹ that, as an advisory body, is playing an active role as an exchange platform and in networking with stakeholders.

“Our interest in science diplomacy is not a fleeting interest. In Europe, we know that investing in others, learning from others and being challenged by others, is the surest way to spark innovation. Innovation that Europe and the Middle East need to remain secure and competitive in global markets.

Science diplomacy is as much about innovation in economic policy, as it is about neighbourhood policy, or even foreign policy. We no longer live in a world where one country can stand alone. Creating an enlarged area of scientific and technological excellence – preventing intellectual migration – brings about economic stability. That stability gives young people the space they need to dream, aspire and develop. Stability brings with it confidence and security.”

Commissioner Carlos Moedas, “Addressing shared challenges through Science Diplomacy: the case of EU–Middle East regional cooperation”, Amman, Jordan, 13 April 2015

⁷⁹ <http://www.edctp.org/>

⁸⁰ <http://europa.eu/globalstrategy/>

⁸¹ <http://ec.europa.eu/research/iscp/index.cfm?pg=sfic-general>

Structured policy coordination between the Commission and SFIC takes place in view of Joint S&T Cooperation Committee meetings and high level policy dialogues with international partner countries and regions. The Forum is also providing input and feedback to multi-annual roadmaps for cooperation with key countries and regions, and country-specific Working Groups are contributing to a more coherent research and innovation cooperation strategy for these countries.

Member States have also contributed to improving framework conditions for research and innovation cooperation across the world through policy dialogues with the EU's partners, as well as through involvement in global fora such as the OECD Global Science Forum and the Global Research Council.

Another aspect of cooperation with Member States and Associated Countries is where the EU participates in their joint research programmes, aiming to integrate national programmes and carry out joint activities, such as in the European and Developing Countries Clinical Trials Partnership (EDCTP). SFIC is also engaging with the Group on Joint Programming to strengthen the internationalisation activities of Joint Programming Initiatives.

Cooperation is also carried out through initiatives such as the Strategic Energy Technology (SET) Plan in the area of energy research and innovation to ensure a coherent European strategy vis-à-vis international partners. For example, as a long-term platform for cooperation at EU level, the SET Plan can benefit multilateral initiatives such as 'Mission Innovation'.

Further action to improve synergies with the actions of Member States could include analysis and mutual learning as regards their international strategies and initiatives; structured policy coordination, and the involvement of more partners from around the world in actions such as Joint Programming Initiatives.

Thematic cooperation targeting new value chains and growing markets

The main reason for cooperating with industrialised countries and emerging economies is to access new sources of knowledge that will help us to develop enabling technologies, jointly tackle global challenges through common innovative solutions, and increase the EU's competitiveness.

Targeted international cooperation in a range of thematic areas is providing businesses in the EU with new business opportunities and access to research and innovation capacities, new value chains and growing markets beyond Europe.

Boosting cooperation on innovation entails putting in place adequate framework conditions and a level playing field, including fair and equitable treatment of intellectual property, access to public procurement and venture capital, common or interoperable standards, and coherent rules for data access and ownership.

It also involves supporting demonstration and piloting activities and providing support for the uptake of innovative solutions and technologies in new markets.

Catching a ride on Brazil's sustainable transport revolution

Some of the most innovative sustainable transport initiatives are being driven by the world's emerging economies. An EU-funded project is making sure that European industry can learn and prosper from these developments. "Europe-Brazil cooperation projects are often aimed at delivering advanced technology from Europe to Brazil," explains the VIAJEO PLUS project coordinator. "This initiative is a two-way learning project. Brazil has demonstrated strong innovation and fast adoption of new solutions on urban mobility." A notable example is the country's Bus Rapid Transit. "Developing an understanding of the policy trends and technological developments happening in Brazil", says the project coordinator, "is vital if European industry is to compete in the Brazilian market and maintain its global competitiveness". The mission of the project is to benchmark outstanding solutions for innovative and green urban mobility in Europe, Latin America, China and Singapore, and facilitate the uptake of these solutions across different cities in these regions.

Further action should continue to develop targeted thematic cooperation on the basis of mutual benefit, optimal scale and scope, partnership and synergy to take advantage of rising research and innovation capacities, new value chains and growing markets across the world.

International cooperation as a cross-cutting priority of Horizon 2020

The EU strategy for international cooperation in research and innovation calls for thematic and geographical priorities to be identified in a systematic and coherent way, and for these priorities to translate into initiatives of the appropriate size and scope, particularly in the context of Horizon 2020.

Horizon 2020 has a strong international dimension thanks to the integration of international cooperation in its Strategic Programming process and by developing work programmes that take into account the priorities that have been identified jointly with the EU's partner countries and regions. Work programmes strongly encourage international participation in consortia and an increasing number of topics offer perfect opportunities for international collaboration and are advertised as such or are even specifically designed around international cooperation.

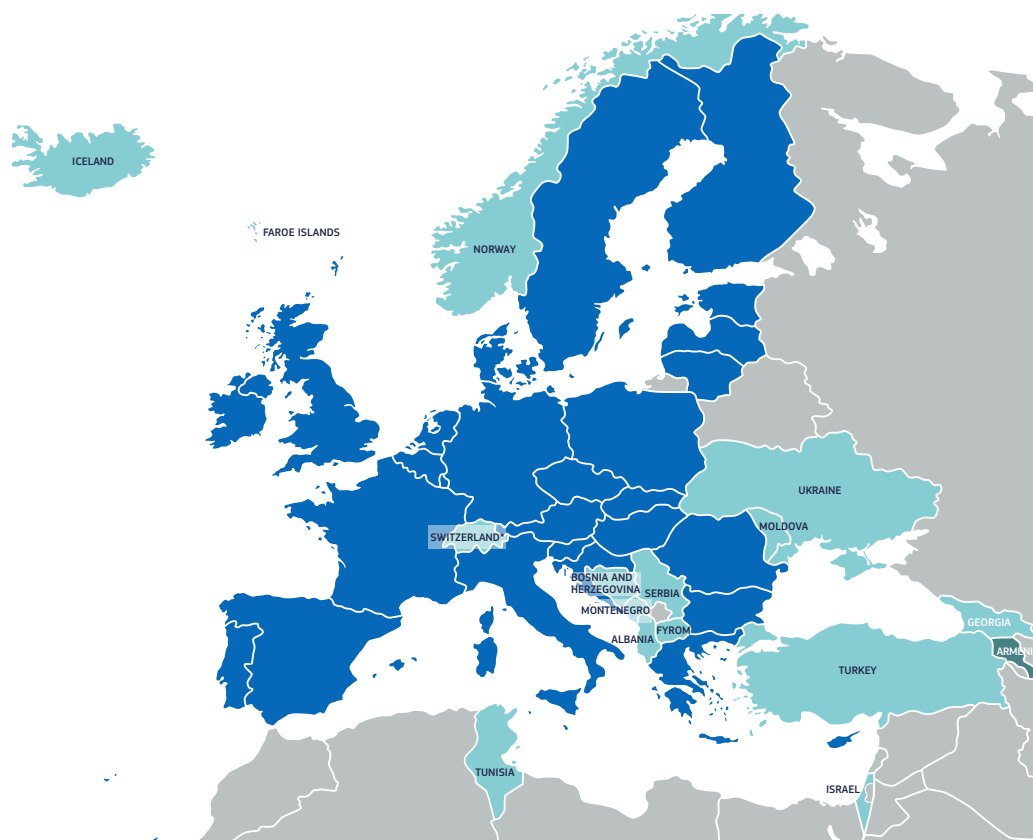
Horizon 2020 is fully open to the participation of entities from across the globe. Currently 13 non-EU countries (Iceland, Norway, Albania, Bosnia and Herzegovina, the former Yugoslav Republic of Macedonia, Montenegro, Serbia, Turkey, Israel, Moldova, Switzerland (*partial association*), Faroe Islands, Ukraine) are associated to Horizon 2020, meaning that legal entities from these countries participate under the same conditions as those from EU Member States, including automatic eligibility for funding.

Association agreements with three more countries (Tunisia, Georgia, Armenia) are in the process of being finalised at the time of writing (spring 2016). In addition, legal entities from some 130 (mostly developing) countries⁸² are automatically eligible for funding from Horizon 2020. Entities from all other countries around the world are fully eligible to participate in the programme if they meet the minimum conditions for participation; however, they are not automatically eligible for funding⁸³.

⁸² http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2016-2017/annexes/h2020-wp1617-annex-a-countries-rules_en.pdf

⁸³ Applicants from such non-EU countries may be granted funding if they meet one of the following conditions: such funding is provided for in a bilateral scientific/technological agreement or similar arrangement between the EU and the country where the applicant is based, the work programme/call for proposals clearly states that applicants based in such countries are eligible for funding or their participation is deemed essential for carrying out the action by the Commission or the relevant funding body.

Figure OW.9: Countries associated to Horizon 2020



*partial association

-  Country associated to Horizon 2020, meaning that legal entities from these countries participate under the same conditions as those from EU Member States, including automatic eligibility for funding
-  Association agreement in the process of being finalised at time of writing (end April 2016)

Further action in this area should continue to strengthen the international dimension of Horizon 2020, including through topics specifically devoted to international cooperation within the different thematic areas that mandate international participation. Efforts should also continue to set up co-funding mechanisms with key partner countries and regions. Finally, communication activities and partnering events should be organised both as regards actions funded by Horizon 2020 and multilateral and bilateral initiatives.

4. CONCLUSIONS

Openness to and engagement with the world is a strategic priority for Europe to produce the very best science and technology, to get research results faster to market and create new business opportunities for R&D-intensive industries, to solve global societal challenges and to have a leading voice in global debates and developments.

Targeted thematic cooperation remains crucial to capitalise on rising excellence, new value chains and growing markets beyond Europe, and to solve societal challenges in the most effective way.

Further action should also enhance the role of the EU in multilateral fora and international organisations to push for larger investments in innovative solutions to the global societal challenges that are at the top of the Union's priority list.

The building of a 'Global Research Area' should continue step-by-step, proceeding region-by-region based on the EU's specific objectives for each region. Stronger synergies with the actions of Member States should also be sought including

through mutual learning and by involving more partners from around the world in actions such as Joint Programming Initiatives.

Science diplomacy should be used more broadly as an influential instrument of the EU's external policies to underpin good governance and policy making and build mutual understanding and trust. The EU approach to diplomacy must use the elevated language of science for its remarkable uniting power.



IMPLEMENTING THE THREE Os

The Commission's Directorate-General for Research and Innovation (DG RTD) is perhaps best known for implementing Horizon 2020, the EUR 80 billion Framework Programme for Research and Innovation.

This work is crucial for boosting research and innovation across Europe. However, we have for a number of years begun to assume an additional role, that of a policy-making department whose mission is to improve the framework conditions for research and innovation in Europe and for obtaining greater impact from the investment made. We develop and implement a range of initiatives (e.g. the creation of a European Research Area) that complement European funding and as such do even more for researchers, innovators and the general public.

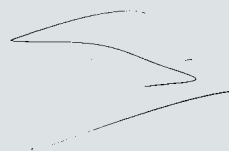
As a policy department, one of DG Research and Innovation's main objectives is as well to ensure that research and innovation is a central part of European policy-making. DG Research and Innovation is very active in shaping the ten priorities of Commission President Juncker, and is making especially important contributions to the jobs and growth agenda, the Energy Union initiative, the Digital Single Market package, EFSI (the Juncker Investment Package), Europe's place in the world and the realisation of the Circular Economy.

None of these initiatives can be successfully rolled out without research and innovation.

The activities of DG RTD are supporting the policy priorities of Commissioner Moedas: *Open Innovation, Open Science and Open to the World*. They are described in this book and will allow research and innovation to flourish at regional, national, European and international level.

The transition to becoming a policy Directorate-General meant separating policy development from programme implementation and project management, with the first task remaining inside DG Research and Innovation, and the second one increasingly entrusted to implementing bodies like Executive Agencies.

But this is only the beginning. There is much more for us to do, in many policy areas, because research and innovation are not just providing answers to tackling our biggest economic and societal challenges, they are also the sources of evidence and advice for sound policy-making.



Robert-Jan Smits,
Director-General,
Directorate-General for Research and Innovation.



Carlos Moedas: **Key Speeches**

KEY SPEECHES

OPEN INNOVATION, OPEN SCIENCE, OPEN TO THE WORLD

A new start for Europe: Opening up to an ERA of Innovation Conference

Brussels, 22 June 2015

On 25 April this year, an earthquake of magnitude 7.3 hit Nepal. To get real-time geographical information, the response teams used an online mapping tool called Open Street Map. Open Street Map has created an entire online map of the world using local knowledge, GPS tracks and donated sources, all provided on a voluntary basis. It is open license for any use.

Open Street Map was created by a 24 year-old computer science student at University College London in 2004, has today 2 million users and has been used for many digital humanitarian and commercial purposes: From the earthquakes in Haiti and Nepal to the Ebola outbreak in West Africa.

This story is one of many that demonstrate that we are moving into a world of open innovation and user innovation. A world where the digital and physical are coming together. A world where new knowledge is created through global collaborations involving thousands of people from across the world and from all walks of life.

Ladies and gentlemen, over the next two days I would like us to chart a new path for European research and innovation policy. A new strategy that is fit for purpose for a world that is open, digital and global. And I would like to set out at the start of this important conference my own ambitions for the coming years.

But first, I'd like to take a moment to look back at how far we've come. When we started this

journey 15 years ago, the European Research Area was conceived as a physical space. We therefore focused on the physical cooperation and mobility of researchers in different countries, and the flow of knowledge across national borders. If we stand back from the detailed policy discussions and look at the bigger picture, we will see just how much progress has been made.

Cross-border research cooperation has become a wonderful, every-day reality. Mobility is also becoming a normal part of the career of every researcher. Around one in three EU researchers have been internationally mobile over the last 10 years. There has been an eight-fold increase in the number of jobs advertised on the EURAXESS site since 2007, with around 10 000 job offers on any given day. Today, we have a single, integrated European programme for research and innovation.

So, now is the time to complete this first chapter of the ERA and Innovation Union. Let us take the final steps. I am working with universities and research institutes to launch the new RESAVER pension scheme by this time next year. This will allow researchers to move more easily between Member States.

In June next year I will convene a meeting with all countries who have introduced national ERA action plans, to complete this first chapter.

At the same time, we must also open the next chapter. The first chapter was about the physical ERA

and bringing together research and innovation. The next chapter must focus on opening up our research and innovation systems and bringing together the physical and digital.

Let me then turn to the challenges ahead. As the new Commissioner for Research, Science and Innovation, I have spent the last eight months listening, visiting Member States, looking at the evidence, developing my own views.

I see fantastic strengths in Europe. We are open, we have diversity, we host great institutions. With Horizon 2020, we are funding research on an unprecedented scale. But we must be honest about the challenges we face.

I see three major challenges:

1. We are too rarely succeeding in getting research results to market. Technologies developed in Europe are most of the time commercialised elsewhere.
2. Although Europe generates more scientific output than any other region in the world, in some areas we fall behind on the very best science. At the same time, there is a revolution happening in the way science works. Every part of the scientific method is becoming an open, collaborative and participative process.
3. Europe punches below its weight in international science and science diplomacy. Our collective scientific importance should be matched by a more active voice in global debates.

So, In order to overcome these three challenges I see three strategic priorities:

**Open Innovation,
Open Science, and
Openness to the World.**

So what do I mean exactly?

Let's start with Open Innovation!

Open innovation is about involving far more actors in the innovation process, from researchers, to entrepreneurs, to users, to governments and civil society. We need open innovation to capitalise on the results of European research and innovation. This means creating the right ecosystems, increasing investment, and bringing more companies and regions into the knowledge economy. I would like to go further and faster towards open innovation.

First, I believe we need to do more to create a regulatory environment for innovation to flourish. How do we make sure that legislative processes that take several years can adapt to technologies that evolve every month? How do we make sure that regulation is based on an innovation principle as well as a precautionary principle?

Second, if we compare the investment levels between the EU and the US one of the biggest differences in the ecosystem is venture capital. There is far less venture capital in Europe, and venture capital funds do not have the scale or scope to grow companies from early stage to mid-cap and from mid-cap to global players.

I would like to address this problem head on through the development of one or several European Fund of Funds that will invest in new generations of great European innovative companies

Third, we need new actions to get more innovation impact out of Horizon 2020. One way we can do this is to create real synergies with the Structural Funds.

Together with Commissioner Cretu, I plan to introduce a "Seal of Excellence" for applicants that are evaluated as excellent but cannot obtain financing from Horizon 2020, to help them access Structural Funds. This will start with applicants to the SME instrument.

This will allow regions to support their most promising companies – those companies that are recognized as excellent at European level.

Fourth, Horizon 2020 has made a huge step forward in supporting innovation. I am very proud of this. But I also see that Europe does not yet have a world class scheme to support the very best innovations in the way that the European Research Council is the global reference for supporting excellent science.

So I would like us to take stock of the various schemes to support innovation and SMEs under Horizon 2020, to look at best practice internationally, and to design a new European Innovation Council. This is not for tomorrow, but I believe we should

discuss it as a major element under the midterm review of Horizon 2020.

Then there's Open Science which is the theme of today's discussions!

I am convinced that excellent science is the foundation of future prosperity, and that openness is the key to excellence. We are often told that it takes many decades for scientific breakthroughs to find commercial application.

“Let me tell you a story which shows the opposite. Graphene was first isolated in the laboratory by Profs. Geim and Novoselov at the University of Manchester in 2003 (Nobel Prizes 2010). The development of graphene has since benefitted from major EU support, including ERC grants for Profs. Geim and Novoselov. So I am proud to show you one of the new graphene products that will soon be available on the market.”

This light bulb uses the unique thermal dissipation properties of graphene to achieve greater energy efficiencies and a longer lifetime than LED bulbs. It was developed by a spin out company from the University of Manchester, called Graphene Lighting, as is expected to go on sale by the end of the year.

But we must not be complacent. If we look at indicators of the most excellent science, we find that Europe is not top of the rankings in certain areas. Our ultimate goal should always be to promote excellence not only through ERC and Marie Skłodowska-Curie but throughout the entire H2020.

For such an objective we have to move forward on two fronts:

First, we are preparing a call for European Science Cloud Project in order to identify the possibility of creating a cloud for our scientists. We need more open access to research results and the underlying data. Open access publication is already a requirement under Horizon 2020, but we now need to look seriously at open data.

This will mean setting standards for the management, interoperability and quality of scientific data. I would like to see progress on this in next 12 months. And I will want to see what further support or requirements for open data should be introduced in Horizon 2020 following the midterm review.

Second, I strongly believe that the time has come for a European initiative on research integrity. This will be a subject of one of the sessions tomorrow and I would like to see the discussion including policy makers, research funders, research institutions and researchers themselves.

Indeed I think we should launch a new European Research Integrity Initiative – with clear standards and mechanisms to tackle scientific misconduct – by the end of this year.

This will not only boost scientific excellence, but it will show to the public that European science is above reproach.

Finally we need to be Open to the World!

Europe is a global leader in science, and this should translate into a leading voice in global debates. To remain relevant and competitive, we need to engage more in science diplomacy and global scientific collaboration. It is not sufficient to only support collaborative projects; we need to enable partnerships between regions and countries.

Challenges in areas like energy, health, food and water are global challenges. And Europe should be leading the way in developing global research partnerships to address these challenges. This means speaking with one voice, and close coordination with Member States' international collaborations. The example of the EDCTP initiative shows that we can do it.

But I would like to go much further and begin building a global research area. This will not happen in one step, but through developing partnerships with other areas, such as China, Latin America and the United States. As a first step, we announced two weeks ago the creation of a Common Research Area at the Academic Summit of Heads of State and Government of the European Union and the Community of Latin America and Caribbean States. I would like to take a similar step next Monday, when I co-chair the EU China Innovation Cooperation Dialogue.

So, during my mandate I commit myself to launch and expand a series of international initiatives.

Let me give some examples:

I will work with Latin America and African partners to launch a common research strategy for the South Atlantic, mirroring what has been done for the North Atlantic under the Galway initiative.

I am working with Member State and partner governments to launch the PRIMA initiative as a joint research programme on water and food for the Mediterranean region.

We should invest more in projects like the SESAME initiative in Jordan that enables researchers from

across this region to work together on world class science.

This conference is our opportunity to complete the current ERA and Innovation Union actions and to move forward confidently towards open innovation, open science and open to the world. This new InnovationERA must be based on actions and not words. I have mentioned a few examples today, but there are no doubt other possibilities and better ideas.

We should not be afraid of testing new ideas and piloting new actions [Drew Faust the Dean of Harvard always tells students: "A key part of any success is the part of you that is willing to fail"]. But we then must have the discipline to stop those which are not working, and the ambition to scale up what works. Research and innovation must take a long term perspective and not be trapped by the past. And we must make sure that each one of our actions brings in new entrants, young researchers, dynamic entrepreneurs, and people who have never been involved in European research and innovation.

This isn't just another Commission conference.

This is your chance to feed your ideas and aspirations into this new strategy. We will find out soon enough what works and what doesn't and we will build on our successes together.

When innovators like LEGO start fusing real bricks with digital magic, when citizens conduct their own R&D through online community projects, when doctors start printing live tissues for patients ... Policymakers must follow suit.

We owe it to the European Citizens.
We owe it to the future generations.

Let's dare to make Europe open to innovation, open to science and open to the world.

SCIENCE WITHOUT BORDERS

Royal Society lecture,
London, 23 March 2015

Professor Poliakoff,
Ladies and gentlemen,
Distinguished guests,

Needless to say, it is a great honour to speak here today. The Royal Society of London is a chronicle of legacies. The legacies of men like Sir Isaac Newton and Charles Darwin. And new chapters created by women like Dame Athene Donald and Ulrike Tillmann.

I don't wish to try to convince you of anything today. I'm preaching to the converted. I simply wish to share my views as a politician, who believes in science and innovation as the true drivers of growth and prosperity, and as unique tools for diplomacy.

The United Kingdom has made countless contributions to the progress of European science and research. We come together 350 years after the first issue of Philosophical Transactions of the Royal Society. The oldest surviving scientific journal. The journal that pioneered peer review. The journal that created an international model for sharing scientific knowledge.

We share a remarkable scientific history and almost limitless potential. The European Union is founded on the principle of openness: to people, commerce, investment and ideas. And, it will be our openness that ensures our global standing in research, science and innovation in the years to come.

That is certain, because today the way we review, access and communicate scientific information is changing fundamentally. Science without borders isn't just about national borders.

The model set by the Philosophical Transactions of the Royal Society is being transformed in the digital age. The way we think about and measure excellence is evolving. Evolving at a time when the physical and digital worlds are merging. New and exciting

industries, rising from the convergence of several disciplines at once:

- Health with information technology.
- Marine ecology with molecular science.
- Robotics in driverless transport.

This is an opportunity to innovate in a very European way: Through diversity of people and talent. Bringing our commercial aspirations into line with the needs of citizens and the limited resources of our planet.

The PharmaSea project is a perfect example. With EU research funding, it brings together 24 partners from 13 countries to study marine microbes, and bioactive compounds. Research that could lead to new medications, antibiotics and nutritional treatments. PharmaSea unites researchers in the fields of marine genomics, biosynthesis and chemical structure analysis. Teaming up with the world's largest free chemical database and top chemical software company – a multitude of disciplines and technologies in action.

The sheer amount of data at our fingertips, the sheer amount of opportunities for collaboration, is overwhelming. The next big challenge is how to bring everything into the same timeline.

I want to make Europe home to each and every new approach. The European Union provides the perfect testing ground for new methods and ideas. We have made sure it is!

We have invested a great deal in each other, because we know these contributions work.

Let me tell you a story.

About ten years ago, Lord Sainsbury, the UK Science Minister was on a plane. He was going to the Competitiveness Council meeting of research ministers. In his briefing was the official UK position to oppose the creation of a European Research Council.

The briefing said there would be no added value in individual, EU-funded grants for basic research. This could be done better by individual member states surely? Fortunately, Lord Sainsbury took a risk. He had listened to scientists, who strongly believed in a European Research Council.

So, when he stood up to present the UK position, he changed it. A man of courage.

Since those days, the ERC has supported close to 5000 grants.

Financing the people whose discoveries can start new industries, create new markets, and improve our quality of life.

People like Norwegian husband-and-wife team Professor May-Britt and Edvard Moser, who discovered Nobel Prize winning proof of the human brain's inner navigation system.

Many of those grants have gone to researchers at British universities, making a huge contribution to scientific excellence in the UK.

The ERC's work is made possible by Horizon 2020. The EU programme for research and innovation funding. The biggest multinational research programme in the world.

Today, science cannot advance in only one discipline, one country or one university. Science must be freed from borders of any kind. A few days ago, I was in Kiev to sign Ukraine's Association Agreement to Horizon 2020. The first time Ukraine has been associated to an EU programme. I told Ukrainian Scientists that we need them, as much as they need us. We cannot walk alone in a world where speed and collaboration are essential.

Horizon 2020 represents thousands of projects, organisations, companies, experts and scientists united by curiosity. Billions of euros dedicated to improving the world we live in. The world we share. The world we will pass on to future generations. It is a radically new and comprehensive approach to the European Union's research funding policy.

Horizon 2020 has brought focus and openness to European science. This is an amazing achievement! And – in just the last five years – Europe has witnessed many great achievements for science without borders. Discoveries made by taking risks together!

Let me take you back to 1993. When the United States' plans for a Super Collider were halted by Congress. 20 kilometres of tunnel in Texas had been dug. Over 2 billion dollars had already been spent. Public opinion was generally favourable. But amid a national recession and mounting costs, political support had faded.

Had it reached completion, the Super Collider would have dwarfed Europe's Large Hadron Collider at CERN. The greatest discovery in physics for a generation. Evidence of the Higgs particle. Might have occurred on American soil, rather than among the suburbs of Geneva.

I can understand the political pressure that brought an end to America's Super Collider. It isn't easy to justify spending money on elusive particles, while citizens face economic hardship. It's risky to invest millions into something you cannot guarantee will work. Investment in science is a long-term commitment. It might pay off in 1 year, or 100 years. It doesn't win elections, but it is the best investment we can make in our prosperity and progress.

When it achieved first beam, more than 10,000 people from 100 countries had worked to build Europe's Large Hadron Collider. Scientists from Iran and Israel, from India and Pakistan, began to study particles at a resolution 1000 times smaller than the proton: united in asking fundamental questions about the laws of nature. Science without borders at a European centre of excellence.

It was at CERN that the World Wide Web was invented. Invented, so that physicists around the

world could share data. An innovation, that would swiftly change communication, commerce and education for over 3 billion people worldwide – with implications for intellectual property, copyright and computing. And it is the Web that is now changing science itself: allowing scientists to collaborate in unprecedented ways. Enabling non-scientists to join in experiments and make new discoveries. Providing wider access to journals. Supporting vast quantities of data to be shared openly.

The world's biggest experiment has had many wonderful and unforeseen results! This month, after two years of planned maintenance and upgrades, the Collider is primed again. Ready to smash particles at twice the energy it did when the Higgs Boson was discovered. And we can only imagine what will be achieved by this multinational cooperation next.

Such bold, frontier research is central to advancing excellence and innovation in an increasingly globalised world. But, how and whether we choose to invest in science and innovation is crucial too. In the negotiations on the European Union's 7-year budget, a tough decision was taken.

In the face of economic crises – and with a reduction, in real terms, in the overall European budget – research funding was actually increased. In this new mandate, the European Commission wants to make more high risk, high value investments in research and innovation, not less.

We want to make sure Europe has the best conditions to benefit from excellence, innovation and openness in science.

If we want to remedy the fact that we still haven't achieved investing 3% of GDP into research and development, we have to try something new...

The scientific community fought hard for Horizon 2020 to have the unparalleled budget it has today. Because it makes sense. Because it creates knowledge and prosperity. I want to bring even more to the table. Does that mean sowing the seeds of innovation through grants and project proposals? Yes! But that also means putting money into high risk, high value investments.

The new European Fund for Strategic Investments will do exactly that: financing projects with high risk, high value profiles: in strategic infrastructure, education, research, innovation and more. 315 billion euros of public and private funding to be leveraged over the next 3 years.

That means more money for European research and innovation, not less. I know that some people are sceptical of fundamental science attracting private investment, or even loans. But let us consider how the Large Hadron Collider was financed. The Collider that has thrown up so much more than expected. The European Investment Bank lent 300 million euros to CERN in the final phase of the Collider's completion. 300 million euros in loans towards the construction of an unprecedented experiment. An experiment no one could be certain would work the way they hoped.

So, a high risk, high value investment from the European Investment Bank was needed to get Europe's Large Hadron Collider off the ground.

Now it's making discoveries and raising up tomorrow's international human capital in a broad range of applied sciences and engineering.

So, I have touched on science without borders in Europe; science that transcends sectors and disciplines; and innovation generated through investment. I'd now like to look beyond Europe, to international research cooperation. What I believe to be Europe's most outstanding contribution to the world: where we have a common challenge, where scientists want to collaborate and where there is a political opportunity, our innate fascination for revealing the secrets of the universe is a powerful, uniting force for mankind.

The journey is as important, if not more important, than the results we achieve. My Harvard Professor, Linda Hill, says we must "embrace creative abrasion". We must amplify, rather than minimise our differences to spark innovation.

That's why I believe in Europe. Our diversity and our differences are the key ingredient for innovation and most powerful when solving the greatest challenges faced by humanity.

In recent months, EU research efforts have been on the front line in the fight against Ebola. The scale of human tragedy caused by the outbreak required nothing less than immediate action: an unprecedented effort to mobilise over 200 million euros of European research funding in a matter of months. Projects to develop vaccines and rapid diagnostics tests were successfully launched. A momentous example of European leadership in international public health research.

And, there have been encouraging preliminary results. Results indicating the antiviral drug (favi-pira-vir), may be an effective treatment for early Ebola disease. The effectiveness of two candidate vaccines is currently being evaluated through clinical trials in the outbreak zone.

It hasn't been easy, but Europe is succeeding in setting new precedents for international cooperation in research. Europe is bringing nations, scientists and citizens together to solve global challenges.

Ladies and gentlemen,

I wish there was time to cover more. I look forward to our discussion in a moment. And I welcome your questions on these and other topics! Allow me to end by saying that Europe cherishes the United Kingdom as part of its community of scientific endeavour. And, I hope that you cherish EU membership for its contribution to science.

Your membership is essential to the global standing of British universities and to their contribution to the British economy! The EU funds British research. It promotes the mobility of British researchers. It creates jobs and opportunities for British scientists. It provides the conditions for British discoveries. And we are always improving EU support to research, science and innovation!

British science thrives in the EU and we thrive because of you. The majority of the UK's top 20 research partners are other EU countries. You ranked first for number of applicants to our previous framework programme. In the last two years of that programme, you received more funding than any other country, including Germany. That's almost 7 billion euros of EU funds flowing to the UK in the form of over 17,000 grants. Earned by your willingness, and ability, to compete for funding based on merit.

So, my ambitions for your place in Europe are immense. And, in my view, your success rests on your openness. On your engagement and contribution to European efforts for progress. On the value of science without borders. The real risk is to draw new borders. I always want to see the United Kingdom at our table. It is because of your participation, that the values of excellence, openness and innovation have been reinforced in Horizon 2020.

Excellence isn't guaranteed by your past, it's made by investing in your future. By investing in our collective future. By removing all borders from science.

As President Shimon Perez once said:

"The value of country is not and will never be measured by square metres of land, but by the number of scientists per square metre."

Ladies and gentlemen thank you for your attention. I look forward to learning from you this evening, and I will do my best to answer your questions. I'm a great fan of everything you've achieved and I will always champion British science in Europe and the world!

Find the Speech online
http://europa.eu/rapid/press-release_SPEECH-15-4658_en.htm

THE DEMOCRATISATION OF INNOVATION

X Symposium Cotec Europa

Rome, 28 October 2015

Your Excellency President Mattarella,
Your Majesty [King Felipe VI of Spain],
Your Excellency President Cavaco Silva,

Ladies and gentlemen, It is my distinct pleasure to be among such distinguished company. It's not often that leaders of your calibre demonstrate such a genuine interest in how their nations' innovations will shape the future of Europe and the world.

President Mattarella has long been a moral compass to his nation as a constitutional Court Justice. At his inauguration, the President presented a strong case for institutional reform and a commitment to tear down the barriers to Italy's economic growth.

Your Majesty has had innovation at the core of Your Majesty's vision for Europe, actively urging Spanish companies to invest in knowledge, to create value through innovation and to compete globally in a sustainable manner.

President Cavaco Silva's distinguished record of public service to my own country includes placing "competitiveness" firmly at the centre of political debate. Well before it was widely understood, President Cavaco Silva rightly saw competitiveness as an issue of value, not of cost, that only through innovation could our companies compete globally and sustainably.

Ladies and gentlemen, distinguished guests, over the past week, I've been in Lisbon and Madrid sharing my ideas on how the digital transition is changing the way we do innovation and science. Today, I'm in Rome – completing the Cotec Europa triangle – and I'd like to talk about what I see as the disruptive implications of a truly digital economy and why we should embrace it.

I'm sure you will agree that digital technologies have already changed how we conduct research,

how we do science and how we innovate, how we produce and sell products and services. Yet, I would argue that we are still at the infancy of the digital revolution.

A web pioneer, Steve Case, says that we are just at the beginning of the third stage of the internet. In the first, the infrastructure of the internet was built. In the second, where we still are, apps were built on top of that infrastructure. The third, just emerging, is when we bring the internet and the digital to the more traditional "infrastructures", like health, transport or manufacturing.

After falling behind in the first two stages of the internet, Europe now has a fresh opportunity to gain an edge and push our economy to a higher stage of innovation and growth. To achieve this edge, we should understand the three ways in which the digital technology creates an impact on innovation.

First, it puts the user in the driving seat. Second, it empowers small players, allowing them to enter and dominate established markets and third, it enables the creation of totally new markets. Let me illustrate each of these three drivers of innovation and then conclude by saying what I intend to do, from the European Commission, to maximise Europe's capacity to reap this opportunity of the digital.

So the first point is about placing the "user" at the centre of innovation. The digital revolution means that innovation and science are no longer the monopoly of the producer or the lab. The user has a say! The internet empowers users to co-develop products, to experiment, to give feedback to producers and it enables wise producers to systematically learn from their users.

Let me tell you the story of Tal Golesworthy a boiler engineer from the UK. Tal was diagnosed with Marfan Syndrome. That meant that his aorta would not last. When he was diagnosed and the doctor said that at some point the vessel could burst, he as an engineer found a solution that has saved his life and so far the lives of more than 100 others. So in the digital world, user innovations can have great impact. Imagine what this will bring in the coming years, as more and more people feel empowered to innovate. This is truly a force for the democratisation of innovation.

Similarly, the digital economy opens the possibility for smaller or newer players to enter an existing market and gain rapid dominance. Think of the Swedish company Spotify, which from scratch, in a few years, was able to enter the music industry and completely dominate it. Or think of Tesla, the American electric car manufacturer, which entered a mature and well established industry and has been growing extremely fast.

There are two factors that explain why Tesla is a very real challenge to the traditional auto industry.

First, they were the first to understand the importance of integrating software – the digital – with the mechanical part of the vehicle. Did you know, for example, that two weeks ago Tesla updated the software of existing cars? So imagine this, in their garages, through Wi-Fi, existing Tesla owners were able to update the software and suddenly their cars gained basic self-driving capabilities!

The second reason why Tesla is a challenge, is the fact that electric engines, combined with rapidly evolving software, are less complex than traditional combustion engines. Thus, the traditional engineering edge from old players is no longer so important. A software whiz-kid may not even have a driving license, but he has the opportunity to bring a concrete innovation to a car. So, with the integration of the digital and the physical, new players can enter existing markets and gain dominance.

The example I gave you involves an American company, but nothing excludes Europeans from this game. Because of our strong industrial base, if we are able to advance in the digitisation of industry, we can

innovate much more and we can gain a competitive global edge and new European players, including SMEs can have the ambition to compete against more established players, yet again, showing digital innovation as a source of economic democratisation.

This brings me to the third way in which the digital impacts innovation. Apart from putting the user at the centre, and enabling new players to enter traditional markets, the digital economy has the capacity to create entirely new markets. This is what Clayton Christensen calls “market creating innovations”. Think of Uber or AirBnB. These are platforms that link free capacity or spare capacity that already exists in society – extra houses or extra cars – with users that need them.

They are able to do this by being at the cutting-edge of the internet, apps, geolocation and mobile technology. They are successful, because they eliminate “pain points” in the interaction – for example, you do not have to have cash with you to use an Uber, and they are also successful because they just work – the design, the service, the process, is easy for the user.

No doubt these new services pose concrete challenges to our regulatory and tax systems. They raise questions of fairness and competition and these cannot be ignored, but my point is that these businesses enable economic transactions that would otherwise simply not happen. This is what I mean when I say that the digital creates new markets and enables a type of innovation that creates new economic opportunities.

Again, this is a force for the democratisation of innovation: empowering the sharing economy, promoting employment and even a more sustainable use of existing resources, which can be positive for the environment.

So, I have presented what are, in my view, the three ways in which digital impacts innovation: digital empowers the user to innovate; digital gives opportunities to newer smaller, more innovative players, to challenge existing markets and digital enables the ultimate innovation, which is the creation of whole new markets with new jobs and new economic opportunities.

A common denominator is the democratisation of innovation. All of us, as consumers, but also a small enterprise, or a part-time driver, or an aspiring musician, or a young scientist at a remote institution - all of us can be innovators and bring positive impact to the world.

How can Europe embrace this opportunity?

The answer is of course complex, but it starts from the bottom-up. It starts with associations such as Cotec that place these issues at the centre of the debate. It continues with projects such as Start-up Lisboa and Beta-i that are bringing forth a new generation of business leaders in Portugal; or with associations like Mind the Bridge networking Italian start-ups with Silicon Valley and it also continues with projects like the Spanish IN3 or South Summit promoting Spanish entrepreneurship, and to which Your Majesty has given so much attention.

Ladies and gentlemen, these examples, I think serve to demonstrate that Italy, Portugal and Spain have the know-how and creative energy to reap the full potential of the digital economy. Some of Europe's best digital success stories are coming from the young businesses in your countries.

On my part, I have the privilege of managing Horizon 2020, the largest programme for research, science and innovation in Europe. Every day we fund the best of the best - the top scientists and researchers

and the most innovative businesses and I have the ambition of creating a European Innovation Council, which can replicate for entrepreneurs what the European Research Council has brought to European scientists.

Because I believe innovators should have the freedom to tell us what they want to do and not the other way around.

Because I believe real innovation comes from bottom-up collaboration and intersection between different disciplines.

This will not be a project for tomorrow. It will take time, and I count on institutions like Cotec to contribute with ideas on how this Council should work. Europe has to be the continent of Open Innovation, Open Science and Open the world.

Your Excellency President Mattarella, Your Majesty, Your Excellency President Cavaco Silva, thank you for your leadership and thank you to Cotec, for placing innovation at the heart of policy debates in Italy, Spain and Portugal.

Walter Isaacson once said about the effect of digital on innovation, "This innovation will come from people who are able to link beauty to engineering, humanity to technology, and poetry to processors [...]. In other words, creators who can flourish where the arts intersect with sciences."

EUROPEAN RESEARCH AND INNOVATION FOR GLOBAL CHALLENGES

Lund Revisited: Next Steps in Tackling Societal Challenges

Lund, 4 December 2015

Minister Hellmark Knutsson,
Professor Jasanoff,
Esteemed guests,
Ladies and gentlemen,

“Science is far from a perfect instrument of knowledge. It’s just the best we have. In this respect it’s like democracy.”

Those are the profound words of Carl Sagan, a man who was a brilliant communicator of science. His words remind us that science – like democracy – will change, develop and transform, but the direction it takes will always rest in our hands: shaped by our desire to contribute a better world. One in which we can all prosper.

Last year the new Commission had to decide the direction we will take, as policymakers for science and innovation, so that European research, science and innovation can contribute to solving the global challenges of our time, while, equally, ensuring the continued progress and prosperity of European society.

Two things were clear. First, our actions must always reflect the European values of openness and diversity, if we are serious about using European research and innovation for something greater than our own gain. And second, we have to embrace change – try new things and be willing to take risks – if we want European research and innovation to remain at the forefront of modernity and economic growth.

It is therefore with great pride, that I look back on the year gone by and consider how this new Commission

has worked with speed and conviction in its first efforts to support European research and innovation that benefits Europe and the rest of the world.

In just one year, we have shown that the European Union is capable of finding new ways to mobilise investment in high-risk, high-reward innovation projects, with 1 billion euro through the new European Fund for Strategic Investments.

In just six months, we were able to establish a new Scientific Advice Mechanism, so that a diverse group of leading European experts can be called upon to inform EU policymaking with independent scientific advice.

And, in a few short months, we demonstrated that the Commission is capable of reacting swiftly in a crisis: intensifying the vital research needed to tackle a global health challenge like Ebola.

Today, I am honoured to mark the renewal of the Lund declaration, a declaration which calls for European research to be freed from its traditional constraints, so that it may have the greatest possible positive impact for society.

It is time to embrace the change that comes with a much more ambitious vision for the future, but if that vision is for Europe to benefit from using its research and innovation to solve global challenges, we must first consider that many of our most familiar academic structures and scientific institutions were established long before science was ever a global endeavour.

In past, individual nations conquered Everest, achieved space flight, navigated to the poles and explored the depths of our oceans. Science was defined by one nation's sprint to the finish line after the other, and scientific institutions and their funding were organised accordingly. Science was a matter of national pride and national security.

There was no political need to share data and little economic incentive to do so, but, by the turn of the century, those trends had already given way to a very different – a very global – dynamic.

New, pioneering nations were investing in science and education. Science was no longer dominated by the same elite club of countries and the challenges were becoming more complex. Whether it was chasing the Higgs particle, finding new drug therapies for HIV/AIDS; or maintaining the international space station, one by one, the latest frontiers in science proved to be insurmountable without collective effort.

It was no longer financially or intellectually viable to reach new frontiers alone.

So we focused on physical cooperation: helping researchers to spend time working in different countries in the European Research Area. Now we take cross-border research cooperation for granted. Europe succeeded in overcoming the physical barriers. Where we still have work to do, is adapting to a world in which how we use and contribute to knowledge is changing.

This is why I have made open innovation, open science and being open to the world, the 3 defining priorities of my mandate, so that European research is best equipped to take on the global challenges of the 21st century.

Open innovation is my first priority, because we live in a time when those without access to the traditional establishment are often the ones doing the most exciting work.

I believe more open innovation in Europe would provide space for all kinds of people to pursue their ideas. People who see the solutions others do not and it is time we let them in.

So, over the next six months, I will be exploring how a European Innovation Council could help innovators succeed in bringing European innovation to global markets and we are innovating finance for innovation through the new European Fund for Strategic Investments; cooperation with the structural funds through the Seal of Excellence and proposing a Fund of Funds as part of the Capital Markets Union, to leverage more European venture capital.

Open science is my second priority, because the days of keeping our research results to ourselves are over. There is far more to gain from sharing data and letting others access and analyse that data.

For example, if sharing big data reveals that a certain kind of cancer activates a particular molecular pathway in most cases and it turns out that there is already a drug approved and available to block the activation of that molecular pathway, clinical trials can begin almost immediately. Saving time, money and lives.

Or if scientists want to monitor the effects of climate change on local ecosystems, they can use open science to engage citizen reporting, and rapidly multiply the data at their disposal.

To make the most of open science opportunities for Europe, I plan to focus on open data, open access and research integrity over the course of my mandate.

Currently the Commission is working with EU member states to launch a European Open Science Agenda. We're considering the merits of developing a European Open Science Cloud, as well as a Research Integrity Initiative and I will continue to advocate the removal of legal barriers to the use of Text and Data Mining techniques for research and innovation.

Open to the world, is my third priority, because there are few forces in this world as engaging and unifying as scientific endeavour. This year the EU was granted observer status for SESAME, home to the first particle accelerator, and to science diplomacy, in the Middle East, and we took the historical step of Horizon 2020 Association Agreements with Ukraine and Tunisia.

It is under this priority that I believe the spirit of the Lund declaration can have a very significant impact. I too see the potential for Joint Programming Initiatives “to become internationally recognised as best practices, [by] involving more partners” from around the world.

So I call on Member States to renew their support and to align their national research and innovation activities with that of the Joint Programming

Initiatives. Particularly in the areas of health, climate, food, water and urbanisation.

Generate new momentum, by giving Joint Programming the political commitment; the opportunities for citizen engagement; and the investments they need to lead the way into a global research area.

Ladies and gentlemen, Carl Sagan also said:

“The scientific way of thinking is at once imaginative and disciplined. This is central to its success. Science invites us to let the facts in, even when they don’t conform to our preconceptions [...] This kind of thinking is also an essential tool for a democracy in an age of change.”

So I ask you to consider not only what we must achieve and overcome in linear terms. I ask you to consider what European research should stand for, in an age of global change and global responsibility.

As I see it, Europe must lead by example. Global knowledge, to solve global challenges, is a web we

weave together. With each new strand it becomes stronger, but there is no way of knowing on whose strand the next dewdrop of inspiration will form, or where the next big idea will land. The only thing that is certain is that we can cast a much wider net together.



References and Acknowledgements

REFERENCES AND ACKNOWLEDGEMENTS

The section '*Recent milestones in the debate on open science*' in the Open Science chapter is adapted from www.scienceintransition.nl. References to the articles in question are listed below:

References to articles listed in Box 2:

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"Says PNAS Editor-in-Chief Inder Verma"	http://www.pnas.org/content/112/26/7875.full
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This book brings together some of the key conceptual insights behind Open Innovation, Open Science and Open to the World and highlights actions that are already taking place or are being prepared. I hope that the ideas and initiatives described in this book will stimulate anyone interested in European research and innovation. I would like it to encourage debate and lead to new ideas on what the European Union should do, should not do, or do differently.

Carlos Moedas

European Commissioner for Research,
Science and Innovation

Research and Innovation policy