European Commission

Excellent Science in the Digital Age

Policy and Actions

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FOREWORD

Innovation is key to the European strategy for recovery and growth. But all the investments and measures to drive innovation can only succeed if there is a solid base of technological and scientific excellence to exploit in the first place. This is why, in FP7 and in the Excellent Science pillar of Horizon 2020 (H2020), we are active right along the innovation chain, from research in Future and Emerging Technologies (FET Open and FET Proactive) to larger, long-term strategic research in key areas (FET Flagships), together with rolling out infrastructures and formulating research policies to ensure that researchers can collaborate wherever they are and that their results and data are open, accessible and available for others to use and reuse. This maximises the benefits of public funding and the uptake and use of its results.

This brochure highlights some of the many EU initiatives and co-funded research projects which address scientific excellence. EU policies and investment in these initiatives fosters scientific progress and helps seed new markets, while strengthening European innovation and completing the Digital Single Market one of the key priorities of the European Commission.

EDITORIAL

The European Commission aims to reinforce and extend the excellence of the Union's science base and to consolidate the European Research Area in order to make the Union's research and innovation system more competitive on a global scale.

A healthy Digital Single Market needs excellent research delivering the technologies and innovations into the market using excellent digital infrastructures, sharing of data and results.

Future and Emerging Technologies (FET) support collaborative research in order to extend Europe's capacity for advanced and paradigm-changing innovation. By fostering scientific collaboration across disciplines on radically new, high-risk ideas and accelerate development of the most promising emerging areas of science and technology as well as the Union-wide structuring of the corresponding scientific communities, the Future and Emerging Technologies are fundamental in pushing the Excellent Science H2020 pillar, together with the European Research Council (ERC), the European Research Infrastructures and the Marie Sklodowska-Curie actions.

Excellent science not only implies excellent research but also excellent research infrastructures (including High Performance Computing) to collectively drive this research together with a comprehensive policy for Open Science, including open access to both data and publications, to widely spread the publicly funded research data, results and know-how.

Open access to scientific publications is now compulsory for all European Commission grants while FET and e-Infrastructures as a whole are participating in the Open Research Data pilot in H2020.

Because modern scientific discovery requires very high computer power and capability to deal with huge volumes of data, a strategy for High Performance Computing (HPC) has been identified as a strategic resource for Europe's future. The European Technology Platform for High Performance Computing, ETP4HPC, has put Europe back on the HPC world map.

The activities carried out by the European Commission in the field of Excellence in Science, are inherently forward-looking, building skills in the long term, focusing on the next generation of science, technology, researchers and innovations and providing support for emerging talent from across the whole of the Union and associated countries, as well as worldwide. In view of their science-driven nature and largely 'bottom-up', investigator-driven funding arrangements, the European scientific community will play a strong role in determining the avenues of research followed under the programme.

We are passionate about what we are doing and hope that, through this brochure, we can pass on our enthusiasm and the potential benefits to everyone – scientists and the general public.

Thierry Van der Pyl

Director

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1 - Open Science: a policy for Europe

Open science is about the way research is carried out, disseminated, deployed and transformed by digital tools, networks and media. Open science relies on the combined effects of technological development and cultural change towards collaboration and openness in research.

Open science makes scientific processes more efficient, transparent and effective through new tools for scientific collaboration, experiments and analysis and by making scientific knowledge more easily accessible. At the same time, Open science stimulates the emergence of new scientific practices, disciplines and paradigms to respond to the new challenges through global distributed collaborations where citizens and society participate as contributors and direct beneficiaries of scientific knowledge.

The European Commission supports harnessing the opportunities of Open Science through policies and funding measures:

- Policies for Open access to scientific information
- Promoting research projects under Horizon 2020 to benefit from Open Science approaches, and to contribute to Open Science development where appropriate
- Supporting citizen science to foster citizens engagement in science
- Developing Global Systems Science to provide scientific evidence in support of policies and to assist policy makers and civil society to collectively engage in societal action
- Complementing Open Science, the STARTS (Science & Technology & Arts) initiative uses the creativity and different perspective of artists to stimulate innovation in ICT

A prerequisite for Open science is Open Access providing researchers, businesses and citizens with improved and free of charge online access to research results, including scientific publications and research data.

Open Access optimises the impact of publicly-funded scientific research, both at European level through FP7 and Horizon 2020 and at the member state level. This is essential for Europe's ability to enhance its economic performance and improve the capacity to compete through knowledge. Results of publicly-funded research can therefore be disseminated more broadly and faster, to the benefit of researchers, innovative industry and citizens. Open access can also boost the visibility of European research, and in particular offer small and medium-sized enterprises (SMEs) access to the latest research results for future use.

Pilot to open up publicly funded research data

OPEN ACCESS

Valuable information produced by researchers in many EU-funded projects will be shared freely as a result of a Pilot on Open Research Data in Horizon 2020. The pilot supported by OpenAire aims to improve and maximise access to and re-use of research data generated by projects. Researchers in projects participating in the pilot are asked to make the underlying data needed to validate the results presented in scientific publications and other scientific information available for use by other researchers, innovative industries and citizens. This will lead to better and more efficient science and improved transparency for citizens and society. It will also contribute to economic growth through open innovation.

The Commission recognises that research data is as important as publications. The Pilot on Open Research Data aims to improve and maximise access to and re-use of research data generated by projects for the benefit of society and the economy.
The Pilot involves Future and Emerging Technologies, e-Infrastructures, LEIT-ICT, and some/parts of some societal challenges (Secure, Clean and Efficient Energy; Climate Action, Environment, Resource Efficiency and Raw Materials; Europe in a Changing World) and Science with and for Society.

The Pilot will give the Commission a better understanding of what supporting infrastructure is needed and of the impact of limiting factors such as security, privacy or data protection or other reasons for projects opting out of sharing. It will also contribute insights in how best to create incentives for researchers to manage and share their research data. The Pilot will be monitored throughout Horizon 2020 with a view to developing future Commission policy and EU research funding programmes. First results in H2020 projects show a considerable success with many projects taking it up, and choosing to open up their research data.

Open access to peer reviewed publications and research results

The vast public investment by the European Commission into scientific research warrants that the resulting output is made freely openly available to all. OpenAIRE, the European Open Access (OA) infrastructure, is giving free access to research publications and associated research data. It provides the infrastructure supporting the EC's open access policies. OpenAIRE offers a multitude of services to its stakeholders: researchers can deposit their scientific output in participating repositories and the system links scientific output to funding. This enables a funder to measure the impact and return on investment by obtaining concrete figures on the follow up of the OA pilot and monitor the circulation of research results.

OpenAIRE also provides an extensive helpdesk system supporting researchers in complying with funder policies, repository managers, and institutions implementing OA policies. It engages researchers in the process, and national contact points on aligning policies with the EC or other member states.

One of the main successes of OpenAIRE is to aggregate local information at a global level, while taking into account socio-cultural and regional differences of the communities involved. This has been successful thanks to the establishment of a truly European, decentralized framework, whereby each member states contributes to the network and supports researchers to deposit in Open Access repositories.

2 - Citizen Science: engaging citizens in science

An important component of Open Science is Citizen Science. "Citizen Science" is one of many terms describing general public engagement in science. It refers to participation in, and/or benefit from the scientific process by the general public or non-professional scientists, and spans a range of levels of engagement: from being better informed about science, to participating in the scientific process itself by observing, gathering or processing data, (e.g. sightings of birds, identifying galaxies, or working out how to fold proteins) to providing resources (lending computer time or direct financing, as in the crowd funding of scientific projects).

More broadly, getting individuals involved in the scientific process offers myriad benefits, from raising the level of scientific literacy and engagement among citizens and the interest of young people in science through projects. Thanks to Citizen Science, a growing number of volunteers are actively contributing to the generation of scientific knowledge and improve the way science is done. This open, participatory and inclusive approach is gaining force throughout Europe thanks to the massive use of new technologies, representing a great potential to address societal challenges and also to "democratise" science, making it more relevant. Citizen Science activities are particularly suited for areas where public involvement would help achieve the results and bring benefits for the public (e.g. environmental monitoring, or Smart Cities).

Every citizen can be a scientist

socientize
citizen science projects

The SOCIENTIZE project built on the concept of 'Citizen Science', which sees thousands of volunteers, teachers, researchers and developers put together their skills, time and resources to advance scientific research. Thanks to open source tools developed under the project, participants have helped scientists collect data to be analysed by professional researchers and performed tasks that require human cognition or intelligence like image classification or analysis, thereby supporting advances in areas from astronomy to social science. For example, the SOCIENTIZE projects 'Sun4All' and 'Cell Spotting' asked volunteers to label images of solar activity and cancer cells from an application on their phone or computer. Analysing this data would take years and cost hundreds of thousands of euros if left to a small team of scientists – but with thousands of volunteers helping the effort, researchers can make important breakthroughs quickly and more cheaply than ever before.

Socientize successfully provided a dynamic forum for the Citizen Science community and produced a White Paper on Citizen Science that will stimulate policies in the field of citizen science. In two years, the project has shown the added value of collaboration and knowledge sharing through digital tools by involving some 12.000 citizens in a large range of science projects from mapping flu outbreaks, labelling images of cancer cells to collective music creation at one of the most exciting festivals in Europe, Sonar**.** One sub-project had prisoners in Portugal participate in labelling images of solar activity, and showed how citizen science can help with social rehabilitation.

Citizens can monitor sound and air pollution in their surroundings

Moving up a level in terms of involvement, the EveryAware FET project enabled citizen observers to monitor and provide data on pollution in their immediate environment.

Citizens collect, share and understand their environment focusing mainly on noise and air pollution data. The developed platform allows for organizing games as well as collecting and estimating environmental information. This new way of accessing environmental information can trigger changes in the citizens' behavior due to an extended awareness of their environmental situation. In addition, the collected data will help researchers to understand the connection between objective ecological data and the citizens' perception of their environment. In this way researchers will get insights into the underlying processes. To enable air measurements by any citizen and to allow for scientific experiments, an affordable low-cost sensor solution in combination with a smartphone and a web service has been developed. Two Apps have been developed to monitor sound pollution and air quality: Widenoise and Air Probe. For the latest, a portable device (SensorBox) can measure the presence of some toxic gasses with a few low cost sensors.
Read more about this project, and check the demo in this video..

3 - Digital Infrastructures:: a science cloud for Europe

The **Digital Infrastructures** or **e-Infrastructures' activities** aim at empowering researchers with easy and controlled online access to facilities, resources and collaboration tools, bringing to them the power of ICT for computing, connectivity, data storage and access to virtual research environments.

It focuses on ICT-based infrastructures and services that cut across a broad range of research disciplines and supports the further development of:

- the high-capacity and high-performance communication network (GÉANT)
- distributed computing infrastructures (grids and clouds)
- data infrastructures
- high-performance computing (HPC) infrastructures
- virtual research communities
- Policies and supporting infrastructures for Open access to scientific information

e-Infrastructures foster the emergence of Open Science, i.e. new working methods based on the shared use of ICT tools and resources across different disciplines and technology domains as well as sharing of results and an open way of working together. Furthermore, e-Infrastructures enable and support the circulation of knowledge in Europe online and therefore constitute an essential building block for the European Research Area.

They are key in future development of research infrastructures, as activities go increasingly "online" and produce vast amounts of data. This support is essential for example to the European Strategy Forum on Research Infrastructures (ESFRI).

The 315 billion euro investment plan launched by the Juncker Commission foresees the creation of a new European Fund for Strategic Investments (EFSI) to mobilise at least 315 billion euro of additional investment over the next three years (2015 – 2017). The role of EFSI is to ensure enhanced risk-bearing capacity and mobilise extra investment, essentially from private sources, but also public sources, in specific sectors and areas. One of the key targets of the Fund is infrastructures in all sectors: Transport, Broadband, Energy, Research and Innovation, Education and training, etc. The investment plan will complement the efforts made under FP7 and Horizon 2020 to further develop and ensure a wider use of research infrastructures at Union level.

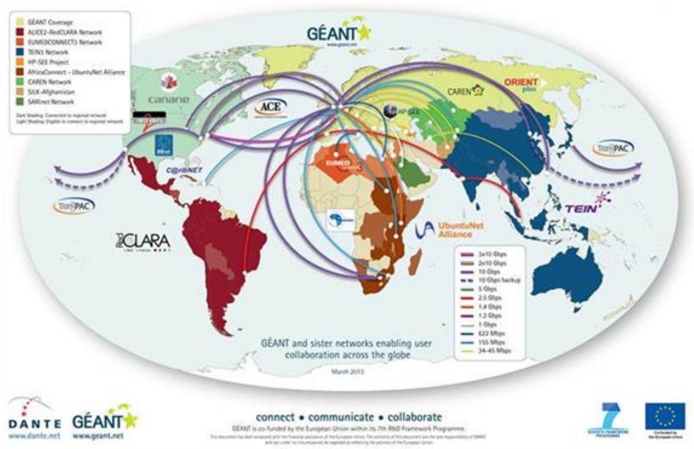
A giant pan-European research and education network

GÉANT is the pan-European research and education network that interconnects Europe's National Research and Education Networks (NRENs).

For longer than a decade the network has enabled the brightest minds across Europe and the world to work together in real time on ground-breaking research in various scientific areas.

GÉANT is a flagship e-infrastructure, key to achieving the European Research Area and assuring world-leading connectivity between Europe and the rest of the world in support of global research collaborations. With fast evolving technology, services and capacity, operating speeds of up to 500 Gbps, and unrivalled geographical coverage to 65 countries outside Europe, GÉANT remains the largest and the most advanced research network in the world and a true European success story.

GÉANT is a model of successful, productive pan-European collaboration, delivering technical innovation through sharing and cooperation. It gives 50 million users at 10,000 European institutions access to the processing power essential to share massive volumes of data needed to study the smallest known particles with the Large Hadron Collider or to tackle global challenges like finding a cure for epilepsy or setting up typhoon early warning systems. GÉANT is operated by DANTE (Delivery of Advanced Network Technology to Europe) on behalf of Europe's NRENs.



A federation supporting research collaboration

EGI, the European Grid Infrastructure, is a federation of over 340 national computing and data storage resource centres, set up to provide computing services and resources to European researchers and their international collaborators.

Launched in 2010, EGI has strengthened the Europe's global lead in research and has given our top-class scientists the computational resources they need, while saving energy and cutting costs. On average, a PC remains idle for around 60% to 85% of the time it could actually be used. Networks like EGI tap into a PC's idle time, and spread massive data problems among the processing capacity of thousands of separate computers. Significant savings can be expected if researchers use the processing power available via the EGI, rather than developing their own alternative networks or supercomputers. EGI-InSPIRE project is giving European researchers access to the aggregated processing power of 370,000 computers in the biggest distributed computing infrastructure ever built. It is used today by 22,000 researchers working in a range of disciplines: from astronomy to finance, from humanities to epidemiology. Since then, EGI evolved into a stable federation spanning 57 countries, with increasingly strong partnerships in Europe and worldwide with other e-Infrastructures, user communities and technology providers. EGI is able to support research collaborations of all sizes: from the large teams behind the Large Hadron Collider at CERN and Research Infrastructures in the ESFRI roadmap, to the individuals and small research groups that equally contribute to innovation in Europe.

The governance is based on the EGI.eu - a not-for-profit foundation established under the Dutch law.

4 - High-Performance Computing: European leadership for Science

High-Performance Computing (HPC) is a strategic resource for Europe's future. Mastering advanced computing technologies from hardware to software has become essential for innovation, growth and jobs.

Today, all scientific disciplines are becoming "computational". While modern scientific discovery requires very high computing power and capability to deal with huge volumes of data, Industry and SMEs are also increasingly relying on the power of supercomputers to invent innovative solutions, reduce cost and decrease time to market for products and services.

There is a clear need to provide for a European world-class HPC capability, both on the supply and on the use side. Despite some valuable initiatives, European HPC is still fragmented in terms of funding and critical mass applications. Due to an upcoming technology paradigm shift in HPC (i.e. the transition from petascale to exascale computing) a window of opportunity is opening for Europe. However, not all countries in Europe have the capacity to build and maintain such infrastructure or to develop exascale technologies. Pooling and rationalising efforts at European Union level is therefore a must.

A strong cooperation with the HPC stakeholders is key for the success of the HPC strategy. A contractual Public-Private Partnership on HPC (PPP on HPC) was established in January 2014 between the Commission and the European Technology Platform for HPC (ETP4HPC) to develop an ambitious R&I strategy. The PPP is aimed to address the development of the next generation of HPC technologies, applications and systems towards exascale and to help achieving excellence in HPC application delivery and use. The budget indicated in the contractual agreement for the PPP is 700 million euros. The PPP on HPC works in close cooperation with the EU co-funded PRACE e-infrastructure initiative providing access to the best supercomputing facilities and services in Europe to both industry including SMEs and academia.

Further support to the implementation of the strategy is provided by digital infrastructures programme and FET.

A partnership for Advanced Computing in Europe

PRACE is the pan-European research infrastructure offering European scientists access to world-class resources and services in HPC (High-Performance Computing) and advanced numerical simulation.

Established since April 2010, PRACE provides access to 6 leading-edge high-performance computing systems (supercomputers) to researchers and scientists from academia and industry from around the world through a peer review process.

By offering this unique aggregated computing power of more than 15 PetaFlops (1 PetaFlops = 1015 computational operations per second) already in 2012, PRACE is allowing its scientific and industrial users to have access to similar capacities and services as their competitors in USA, China, Japan or Russia. Since this level of resources and diversity of HPC architectures was clearly unreachable for any single European country, the rationale of PRACE was to unite efforts from European countries in order to sustain scientific and industrial competitiveness of Europe.

Additionally, via the PRACE supports users and user communities in porting, scaling and optimizing their applications to fully exploit the capabilities of the PRACE systems. The PRACE Implementation Projects also run an extensive training programme and operate 6 PRACE Advanced Training Centres (PATC). These trainings sessions, open to industry, are covering themes such as programming languages and models, code optimisation, pre/post processing, visualisation of large volumes of data, use of open source tools for industry as well as best practises for using its large-scale HPC systems.

Computers have been doubling in performance every two years for the last forty years but we are reaching the physical limits of what we can achieve with current semiconductor technology. The MONTBLANC project is looking to shake up the way in which computer processors are designed and made. The good news is that computers with higher performance will also lead to less power consumption; a win for computing and a win for the environment.

The MONTBLANC project brings together leading researchers from Spain, the UK, France, Italy and Germany with the aim of delivering supercomputers that could revolutionise the way we work. These new machines would be built around 'exascale processors' – processors that can carry out in the order of 10 to the power of 18 (1, followed by eighteen zeroes) operations a second. It's also some nine orders of magnitude faster than your current home or laptop computer.

Read the project story and a watch the project video.

5 - FET: Future and Emerging Technologies

The EU's emerging technologies research focuses on forward-looking ideas that are high-risk, but high pay-off. Future and Emerging Technologies (FET) supports long term research to create new technologies, with a special focus on topics that do not fit easily into other areas of the Framework Programmes such as multidisciplinary research. FET mission is to turn Europe's excellent science base into a competitive advantage, supporting projects as seeds for future industrial leadership and potential solutions for societal challenges.

FET consists of three complementary schemes which work together towards a common mission of nurturing new & emerging foundational trends in future technologies:

- FET Open supports a bottom-up approach for exploring novel and visionary ideas;
- FET Proactive fosters transformative research through a set of focused thematic initiatives;
- FET Flagships are visionary, large-scale, science-driven research initiatives that tackle grand science and technology challenges.

An Infographic representation of FET FP7 projects shows the participation per country and the distribution in participation, number of projects and funding between FET Open, FET Proactive and FET Flagships schemes (320 FET projects received a total budget of €820 million).

5.1 - FET Open & FET Proactive: Investing in ground-breaking technology research

From CYBERHAND FET project to clinical applications: the bionic hand!

About 15 years ago, FET launched the first calls on the NEURO-IT topic, exploring ways to understand how information is communicated in the nervous system and how to link this to conventional engineering devices (ICT). The CYBERHAND project (2002-2005) came from one of these calls, with the goal of developing a robotic hand that could mimic the mechanical functions of a natural hand and be controlled by signals from the nervous system. While the project was able to demonstrate a mechanical hand, the task of direct interfacing to the nervous system to enable a natural control and sense of touch proved to be beyond the project's reach.

Patient testing the artificial hand

Then,, another FET call lead to the funding of the NEUROBOTICS project (2004-2007), which continued the work on how to connect robotic artefacts to the nervous system. One of the results of this project was the development of an electrode that could be implanted into a patient's nerve to enable the control of an external device via nerve impulses. This prototype electrode was subsequently tested in a patient for a period of 1 month, and the patient was able to control a robotic hand, but without any sensory feedback.

Following further refinement of the electrode in the ICT project TIME, a second clinical trial took place in the LIFEHAND2 project (using Italian funding, 2013) where the patient whose hand had been amputated was able to regain a sense of touch using the artificial hand.

The ongoing FET project NEBIAS continues this work with the aim of developing arm/hand prosthesis for upper limb amputees.

FET supports excellent research and excellent researchers

Nobel Prize laureates in Future and Emerging Technologies

In 2012, the Nobel Prize in Physics was awarded to Professors Serge Haroche (France) and David J. Wineland (USA) for "ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems". At that time, Prof. Haroche participated in the project AQUTE, funded within the FET-Proactive initiative Quantum Information Foundations and Technologies. AQUTE aimed to understand and exploit the quantum nature of information using atomic, molecular and optical (AMO) systems. Also within the recent FET-Proactive Quantum ICT initiative, Prof. Haroche is currently a partner of SIQS project (ending 2016). SIQS project purposes to develop systems based on direct and deterministic interactions between individual quantum entities involving large-scale entanglement. The development quantum based information systems is considered a main path to outperform classical and the overcome of the current limits of semiconductor-based (CMOS) ICT technologies

In 2014, the Nobel Prize in Physiology or Medicine for 2014 has been awarded to John O´Keefe (American-British) and to May-Britt Moser and Edvard I. Moser (Norway), for their discoveries of the "Grid" cells that constitute a positioning system in the brain. Edvard Moser is leading the GRIDMAP project, with participation of May-Britt Moser, funded within the FET-Proactive Neuro-Bio Inspired Systems initiative. The GRIDMAP project uses new and developing knowledge on Grid cells and on how the brain functions in order to develop better computer systems.

Until now (early 2015), 9 Nobel Prize laureates have been involved in FET projects.

FET supports high-tech SMEs and some projects bridge the gap between lab and market with spin-offs creations (see MEMO)

Revolutionary brain devices

Neuroelectrics, a spin-off of the high-tech SME Starlab, is a good example. Thanks to EU funding within the FET Open project HIVE, Starlab, which coordinated the project, developed two revolutionary devices which are commercialised through its spin-off Neuroelectrics, which is currently expanding worldwide.

The first device is Enobio, a wearable medical tool and wireless sensor system for the recording of electroencephalography (EEG). EEG is commonly used for the detection and study of epileptic episodes and for the study of sleep disorders, also having great potential for detecting neurodegenerative diseases, for stroke rehabilitation and for non-verbal communication. With Enobio, EEG is mobile and monitoring can be done at home.

The second device, Starstim, is a wireless brain stimulator which applies weak transcranial electrical current. This stimulation can relieve pain (migraine headache, multiple sclerosis pain, fibromyalgia, etc) and could be used for depression treatment, post stroke rehabilitation and cognitive enhancement. Ana Maiques, co-founder of Starlab and Director of Neuroelectrics, was one of the winners of the European Women Innovators Award 2014. The project HIVE aimed to advance state-of-the-art in fundamental neuroscience research, neurology diagnosis and therapy. Moreover new applications of these technologies could cross field barriers, as research within the HIVE project achieved non-invasive direct human brain to brain communication for the first time, works that were published in the prestigious research journal PLOS One (August 2014).

5.2 - FET Flagships: addressing major science & technology challenges for Europe

Flagships are visionary, science-driven, large-scale research initiatives addressing grand Scientific and Technological (S&T) challenges. They are long-term initiatives bringing together excellent research teams across various disciplines, sharing a unifying goal and an ambitious research roadmap on how to achieve it.

In October 2013 the European Commission launched two FET Flagship projects: Graphene and The Human Brain Project (HBP).

Each of the two Flagships will establish Europe as the leader in their specific domains and a pole of attraction for international cooperation; they will nurture creativity, flair and talent, attracting the best minds all over the world and creating the skilful multi-disciplinary researchers Europe needs. By leading, inspiring and integrating efforts, Flagships become a new partnering model for long-term European collaborative research in the context of the European Research Area (ERA).

Each Flagship will have a budget of around 1 billion Euros for 10 years. Half of the Flagship budget is planned to come from the EU funds. The other half would come mainly from the Member States and possibly the private sector, through financing Partnering Projects and also through in-kind contributions to the Flagship from participating organisations. To support the Member States in coordinating their contributions to the Flagships, the Commission is financing an ERANET action, called FLAG-ERA. The Coordination and Support Action TAIPI will support and strengthen FET Flagships by undertaking impact assessment activities and collecting information need for policy making (http://www.taipi.eu/ under construction).

The European Commission published in September 2014 the FET Flagship Staff Working Document, announcing the implementation model for the Flagships in H2020 (overview and presentation).

Further information is available here.

FLAG-ERA

The FLAG-ERA ERA-Net project includes representatives from ministries and research funding organisations in Europe's Member States and Associated Countries, with the goal of defining and jointly implementing national and European activities supporting the two FET Flagship initiatives, including Trans-national Calls for Proposals.

GRAPHENE FLAGSHIP

Graphene is a form of carbon in which the carbon atoms are arranged in a honeycomb pattern, in layers one atom thick. This transparent, flexible material has many unique properties. For example, it is 100 times stronger than steel, and conducts electricity and heat with great efficiency. It is therefore the subject of intensive worldwide research, with a vast range of potential applications and opportunities for commercial exploitation.

The Graphene Flagship began on 1st October 2013. It has 142 academic and industrial partners in 23 countries, and almost one third of its partners are industrial. The Flagship has a projected total cost of €1bn over 10 years, with half the funding from the European Commission, and the remainder from Member State programmes and other sources including industry. The project is now still in the €54m ramp-up phase, which runs to the end of March 2016. This will be followed by the steady-state phase, under the Horizon 2020 framework programme, with an expected EC funding of €50m per year.

In the first year, the Flagship has produced more than 150 publications in major scientific journals (including a special dedicated issue from Nature), more than 5 patent applications, and many demonstrators and prototypes. The Flagship has also set up a semi-permanent exhibition for the general public, in a science museum of Goteborg, that will later travel to other European cities.

The Flagship partners develop numerous practical applications for graphene. These include flexible computer displays, sensors, medical and bioengineering technologies, filtration, super-strong composites, and energy storage, such as for example batteries.

The Graphene Flagship also covers other layered nanomaterials whose development was inspired by graphene. Graphene is just the first of hundreds of possible two-dimensional materials. Especially exciting is the possibility of stacking two-dimensional elements to create materials not found in nature, with electrical, mechanical, physical or thermal properties tailored for specific applications. Many European companies are now joining the Flagship's effort to take graphene and related materials from the lab to the market.

Mass production of graphene at low cost is a priority when it comes to real-world applications and product development. A number of Flagship partners are looking at the high-volume manufacture of high-quality graphene, and the tailoring of material properties for specific applications.

For example, Flagship partners recently demonstrated the world's first flexible display with graphene incorporated into its pixel backplane. Combined with an electrophoretic imaging film, the result is a low-power, durable display suitable for use in many and various environments.

Graphene is also important in photonics applications. Optical fibres form the backbone of terrestrial and trans-oceanic telecommunications systems, and enable super-fast home broadband. Flagship partners recently demonstrated faster photodetectors for these infrared fibre-optic systems, based on wafer-scale graphene. The devices have data rates of up to 50 gigabits per second, and display excellent signal integrity.

In the area of electrical energy storage, Flagship partners are developing improved rechargeable batteries, for example by using spreadable graphene ink as for the anode. These batteries have a higher performance than conventional lithium-ion cells, with a 25% improvement in energy density. Graphene is also being used in more powerful supercapacitors. These breakthroughs will be particularly important for electric vehicle applications.

Summary of outcomes of 1st year periodic review

Human Brain Project

The Human Brain Project (HBP) Flagship was also launched on 1st October 2013. It aims to achieve a multi-level, integrated understanding of brain structure and functions through the development and use of information and communication technologies (ICT).

The HBP Flagship is bringing together more than 112 partners from 24 countries. In its first year the Flagship has made significant progress on all fronts; these were reported at the project's annual summit (Heidelberg, end September 2014) that brought together more than 300 researchers. The project has published more than 50 papers in major scientific journals. HBP is developing six ICT platforms; neuro-informatics, medical, neuro-robotics, neuro-morphic, brain-simulation and supercomputing.

The technologies and ICT platforms being developed within the Flagship will enable large-scale collaboration and neuro-scientific data sharing, modelling of the brain at different biological scales, federated analysis of clinical data to map diseases of the brain and the development of brain-inspired computing systems. Through the ICT Platforms, scientists, clinicians and engineers will be able to perform diverse experiments and share knowledge with a common goal of unlocking the complex structure and functioning of the brain. With an unprecedented cross-disciplinary scope, the HBP Flagship seeks to integrate neuroscience, medicine and computing researchers around brain research and benefit the global scientific community.

Specific highlights and results after the first year of research work in the Flagship include:

- The European Institute for Theoretical Neuroscience (EITN) was inaugurated in Paris in March 2014.
- HBP researchers released the highest resolution 3D map of the human brain (BigBrain) that exists. It will serve as a reference for the HBP Human Brain Atlas.
- HBP has defined a new way to categorise patient brain data for better identification of brain diseases and attracted the interest of the first 18 hospitals all over Europe to join HBP's medical platform.
- The project has implemented data mining algorithms in brain-inspired hardware, and developed a "virtual" room to test brain models in robots and virtual "bodies" to study emergent cognition and behaviour. The project has now three computer suppliers working on the specifications for the next peta-scale HBP supercomputer.
- In the area of High Performance Computing, pre-commercial procurement of research and development on “interactive supercomputers” has been successfully launched. Interactivity will be the key feature of future super-computers for brain research.
- Brain-inspired neuromorphic chips to rival today’s high-performance computers are now being tested by HBP researchers for their versatility in solving modern day computing challenges.
- The HBP has applied brain simulation techniques originally developed for the neocortex to a new brain region: the cerebellum.
- Key (missing) data on the cellular organisation of the mouse brain has been generated and the technique to determine all genes switched on and off in single neurons has been established, a first step towards isolating all the genetic types of cells in the brain.

The Flagship has also launched a Museums and Educational programme and held its first ethics and society stakeholders forum with specialists on medical informatics, law, ethics and social sciences.

Summary of outcome of 1st year periodic review

Websites

For detailed information on our activities, we invite you to consult the following websites:

Open science

Citizen science

Digital infrastructures

HPC

FET

FET Flagships

Twitter Accounts

Follow us on Twitter for policy developments and project updates.

@ICTscienceEU

@eInfraEU

@fet_eu

@FETFlagships