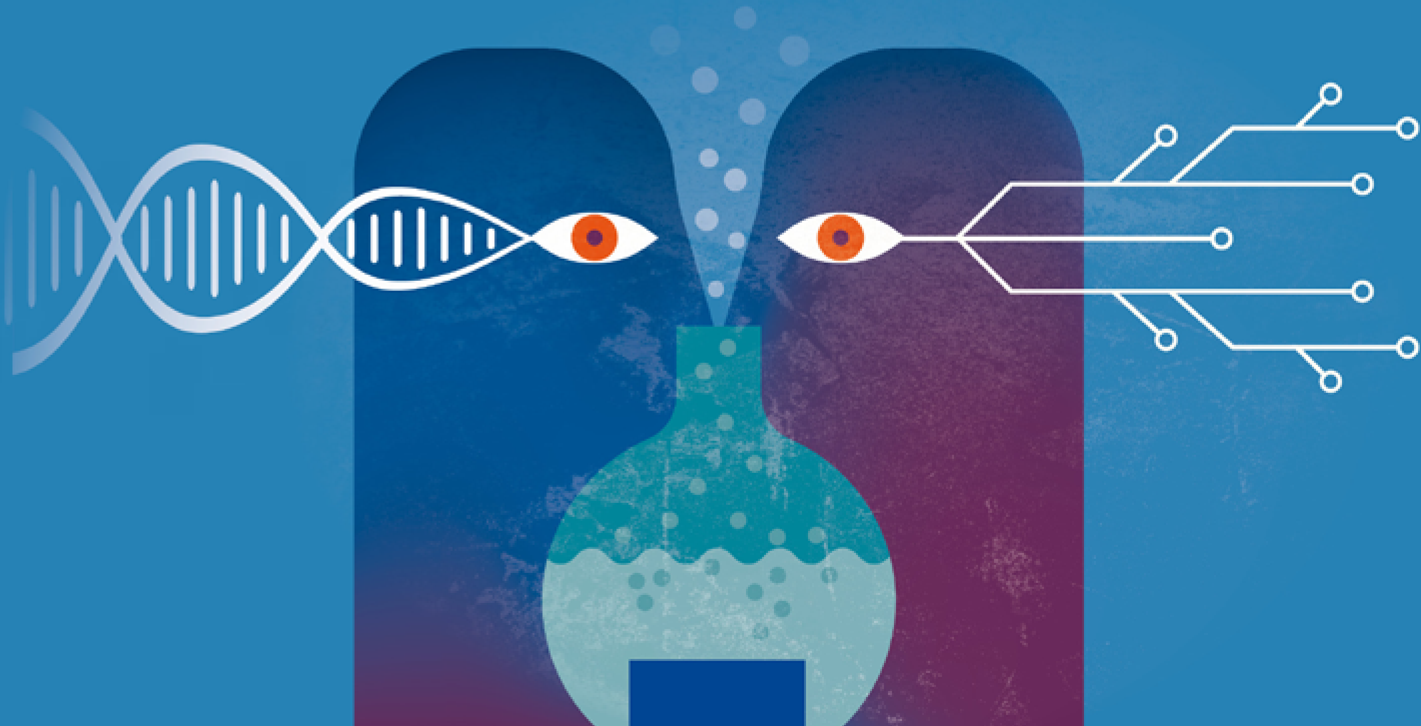
European Commission

From great science to thrilling technology

Europe's Future and Emerging Technologies programme



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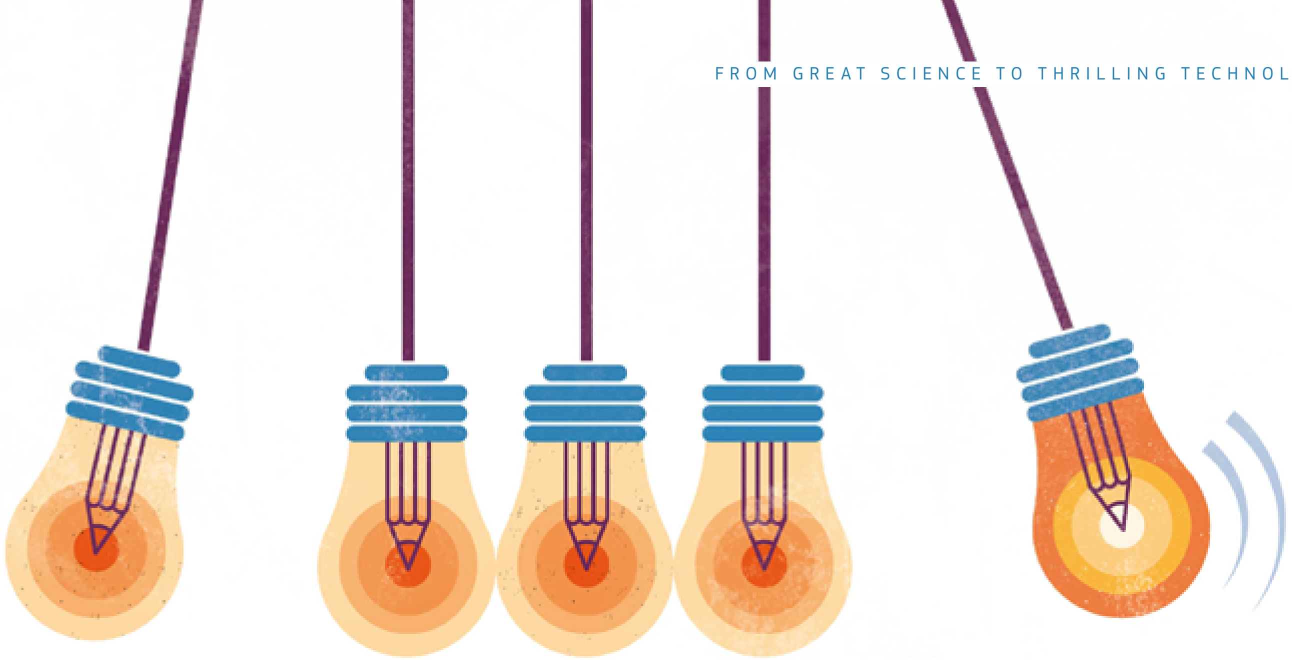


Foreword

For more than 20 years the Future & Emerging Technologies (FET) programme has been a landmark in advanced European science and technology. Over the years, it has supported research that led to amazing developments in a wide variety of areas, from a bionic hand to robotic plants, from synthetic brains to quantum technologies, from modelling epidemics to creative machines.

By providing support to a unique mix of high-risk, long-term, multidisciplinary and collaborative frontier research projects, the FET programme continuously pushes technological boundaries into unexplored territories.

FET is exceptional in the way that it stimulates fresh synergies, cross-fertilisation and convergence between different scientific disciplines (for instance, biology, chemistry, nano- and molecular science, computer science, neuro- and cognitive science, ethology, social science, economics) and with the arts and humanities.

This booklet is intended to give just an idea of the rich range of FET projects. The list of topics and achievements in the FET programme is remarkable and making a selection has been a challenge. Indeed, all FET projects could be showcased here – they have all contributed to changing the face of European technology and innovation.

Join us on this journey to discover just some of the achievements made by FET projects in recent years.

And remember: much more is yet to come!

What is FET?

The Future & Emerging Technologies (FET) programme is all about transforming advanced scientific ideas into radically new technologies for the future. It does this through a unique combination of high risk, long term, multidisciplinary and collaborative frontier research. The programme consists of three complementary schemes: FET-Open, FET-Proactive and FET Flagships.

• FET-Open uses a bottom-up approach for exploring novel and visionary ideas for radically new technologies. It accommodates new and alternative ideas, concepts or paradigms that are so early-stage, high-risk and out-of-the-box that they cannot be supported elsewhere in the Framework Programme. The scheme is truly open in scope as there are no restrictions on themes that can be funded, as long as they are relevant for new future technologies.

• FET-Proactive fosters new technological paradigms through a set of complementary projects focused around specific proactive themes. The novel and non-conventional topics addressed aim to consolidate a solid baseline of knowledge and skills, spearhead further research and create new multidisciplinary research and innovation communities with the capacity to take-up Europe's scientific and industrial leadership in new promising areas of technological development.

• FET Flagships are visionary, science-driven, large-scale, long-term (10 years duration) multidisciplinary research initiatives oriented towards a unifying goal, with a transformational impact on science and technology and substantial benefits for European competitiveness and society.

To date, two Flagships are running: Graphene and the Human Brain Project. A third one on Quantum Technologies will start in 2018.

FET continues to promote interdisciplinary research beyond what is known, accepted or widely adopted by supporting novel and visionary thinking to open promising paths towards powerful new technologies. The FET programme is set to become Europe's open, virtual and interdisciplinary science-tech campus, a "place" where Europe's best teams collaborate to realise new ideas, and where game-changing developments in science-and-technology are coming from. It will boost European-wide capacity for radical technological innovation, foster new generations of researchers and innovators that will connect the creativity of researchers and the rest of society in new ways.

To discover more about FET projects beyond this brochure, visit the video playlist dedicated to FET.

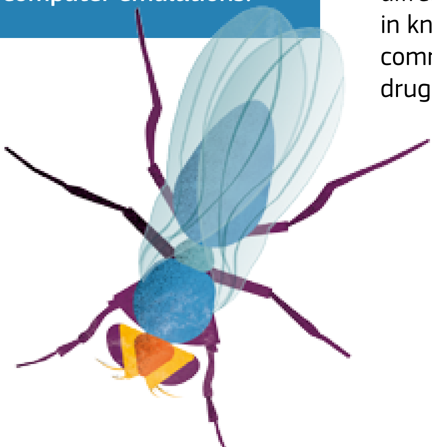
FET: A patchwork of research frontiers

Under Horizon 2020, the European Framework Programme for Research and Development from 2014 through 2020, FET is addressing any kind of future and emerging technology1. The research supported by FET is best characterized through its flavour and attitude of visionary, high-risk exploratory and collaborative adventure in unknown areas of technology. In this booklet you will find example project illustrating a variety of research frontiers. Sometimes though, the most fascinating projects don't really fit in any box. Projects on communicating plants, on hybrid societies of robots and cockroaches, on bacterial computers or on creative machines defy traditional boundaries between technologies. Remember that technological paradigms that are obvious or emerging today, like real-time translation, autonomous robots, personalised medicine, opto-genetic technologies in neuroscience or artificial memory implants all started from what seemed impossible ideas years ago.

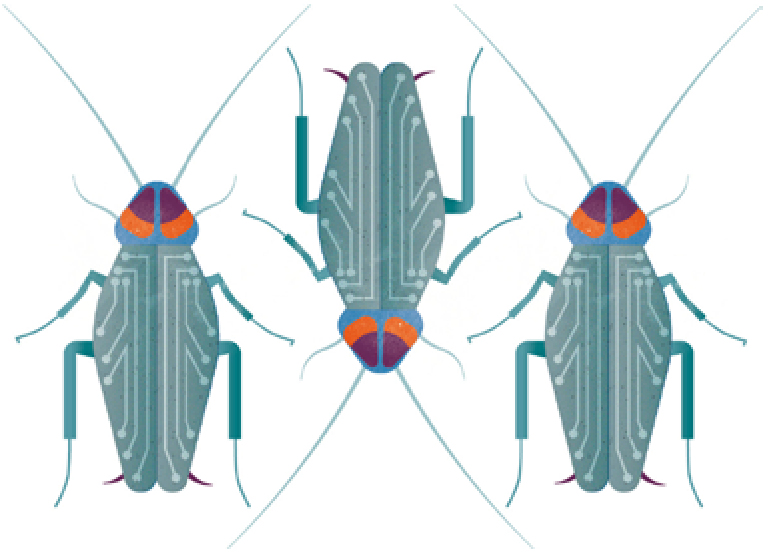
1 The FET programme has its historical roots in a Basic Research programme for Information and Communication Technologies, going back as far as FP2-ESPRIT 2 - European strategic programme (EEC) for research and development in information technologies (ESPRIT), 1987-1992. The programme's emblematic Open scheme was first introduced in FP3-ESPRIT 3 (1990-1994). In FP4-ESPRIT 4 (1994-1998) it was renamed Long Term Research. The name Future and Emerging Technologies (FET) was first used in FP5 (1998-2002).

FET research frontiers in Artificial intelligence

Understanding by building is at the heart of research in Artificial Intelligence (AI) and cognitive systems. Various FET projects explore synergies between cognitive science and the neurosciences, but also biology, material science, the social sciences and humanities to create artificial intelligent systems. Creativity, context awareness, associative reasoning, learning, adaptation, evolution, emotion and social intelligence are some of the topics addressed in FET projects. Machine learning from 'big data' is now the theme in mainstream AI, but FET projects are already stepping ahead, for instance with research on creativity (as opposed to problem solving), learning from 'small data' (as opposed to big), the role of culture and other social phenomena (as opposed to focus on intelligence as an individual's trait), or synthetic AI to achieve intelligence on new physical substrates (polymers, biological tissue, bacteria) rather than with in-silico computer emulations.



MINIMAL - Animals, no matter how simple or complex, display a remarkable capacity for learning. The Minimal project focused on the learning processes in a relatively simple animal, the fruit fly larvae (maggots). Despite having fewer than 10 000 neurons, this creature is capable of learning quickly and flexibly from certain cues that lead them towards good things and away from bad things. Understanding the specific mechanisms behind the learning process could have important applications for technology, such as the development of self-learning small robotic devices, but the research could benefit other fields as well, such as the information environment. For instance, while current trends in computing often rely on big data, it is notable that in nature, animals often learn with very little data to predict associations (such as the maggot's ability to detect good food). The project explored a bio-paradigm of learning model with very little data as opposite to big data computing trends. The biological model was tested with three different embodiments. Besides general advancement in knowledge, the project results are potentially commercially applicable in brain disease models and drug discovery.

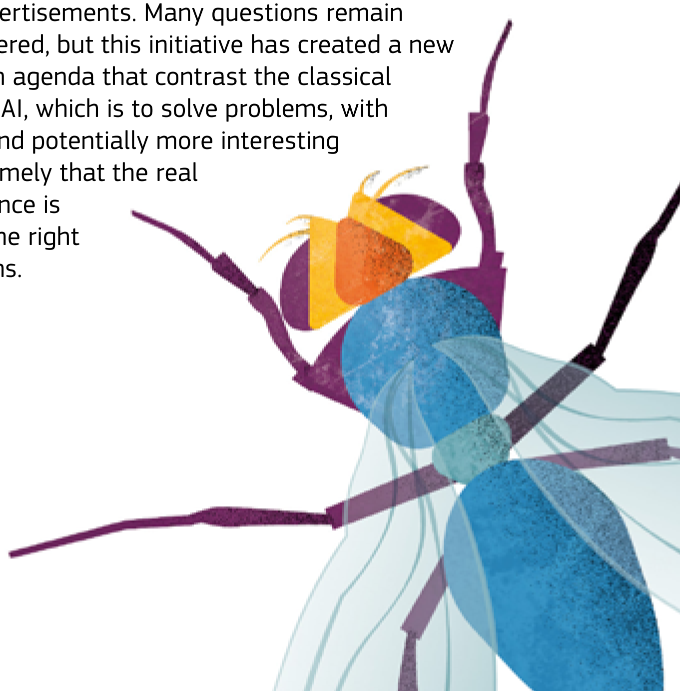


FET'S LITTLE ZOO

Fruit flies (Drosophila melanogaster) and their larvae are but one of the species of tiny creatures that FET projects have been looking at. Well ahead of its time, the project BION attempted to build the brain of a common snail (Cornu aspersum) in a specific polymeric mix that would spontaneously recreate a memristor-based learning neural network. The sense of smell in moths (Manduca sexta) was studied at molecular and neural levels in the project iChem, and experimented for smell-based navigation and chemical communication in mobile robots. The amazing idea of switchable odours is explored, this time with fruit flies, in a much more recent FET project, NanoSmell. The project Si.Elegans emulated brain and body of a common worm, Caenorhabditis elegans, using an amazing optical set-up to implement the nematode's connectome, an installation that one would expect in a science museum rather than in a research lab. The models developed here are used by the C.Elegans research community, through open science platforms like OpenWorm and WormAtlas. There have also been projects studying ant colonies, or hybrid ecologies of tiny robots and… cockroaches.

Computational creativity

Can a computer be truly creative? Can it invent new concepts or find new design solutions? And would such artefacts pass the test of human judgment on how interesting, useful or beautiful they are? The FET initiative on computational creativity set out to answer these questions with projects CoInvent, ConCreTe, Lrn2Cre8, WHIM, and the Coordination Action PROSECCO. They came up with systems that can compose original music that imitates the style of any composer (such as 'Let it be' in the style of Bach), or that can harmonise musical scores in interesting new ways. Programs can invent interesting concepts by analogy, or formulate mathematical hypothesis that make sense. Chatterbots create chat streams that could be done by creatives. As a result of machine learning research, the computer wrote music for the first concert ever in which all of the music played had been written by a computer. The What-If Machine created fictional ideas with real cultural value for artefacts such as stories, jokes, films, paintings and advertisements. Many questions remain unanswered, but this initiative has created a new research agenda that contrast the classical view on AI, which is to solve problems, with a new and potentially more interesting view, namely that the real intelligence is to ask the right questions.



FET research frontiers in Human – Computer Interaction

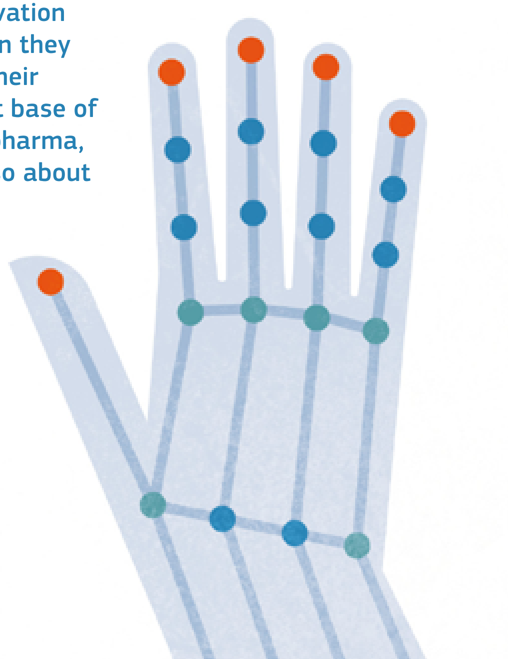
The screen, the keyboard, the mouse: is that how we will interact with computers forever? Of course not! In the future computers may speak and understand natural language, engage all our senses (touch, smell, etc.), understand what we want ('Help me!') from the context, or adapt to our mood. Embedded in our living environment or' disguised' as robots, everyday objects, in our clothing or behind 3D interfaces, we will simply forget about them and enjoy the magic they create for us.

GHOST - Exciting new technologies that allow users to change the shape of displays with their hands promise to revolutionise the way we interact with smartphones, laptops and computers. Imagine pulling objects and data out of the screen and playing with these in mid-air. The FET project GHOST aims at creating shape-changing interfaces, display surfaces made of malleable materials that can change into and retain arbitrary shapes, displaying output from a computer system and allowing new actions. This breakthrough in user interaction with technology allows us to handle objects, and even data, in a completely new way. For instance, a surgeon will be able to work on a virtual brain physically, with the full tactile experience, before performing a real-life operation. Designers and artists using physical proxies such as clay can mould and remould objects and store them in the computer as they work. The researchers have also worked with deformable interfaces such as pads and sponges for musicians to flex to control timbre, speed and other parameters in electronic music. GHOST has produced an assembly line of prototypes to showcase shape-changing applications that could be the future of interactive devices.

SKAT-VG - Humans have surprising abilities in communicating sound. Our use of voice and gestures is not limited to verbal communication and music, as it allows us to mimic a wide range of everyday sounds and to convey a sonic idea effectively. The goal of the project was to expand scientific understanding around voice- and gesture-based sound communication. To make this happen, the team joined their skills in perception, voice production, gestures, machine learning, sound synthesis, and interaction design. They also introduced new tools and methods for sketching in sound design. The project has demonstrated that vocal/gestural sketching can be as immediate and effective for sound design as drawing on paper is for visual design. The project findings and developments have the potential to re-define current sound design practices by including vocal and gestural interaction and cooperation in the creative flow. Sound designers will be able to get an audible digital rendering of an idea of sound directly through a vocal imitation. It will also be possible to further manipulate the sound sketch through voice and gesture, and to work cooperatively on it in a meeting with peer designers, clients, or other stakeholders. In the near future, designers might sketch novel responsive sounds, for a car or for a coffee maker, by using the whole expressive potential of their voice and body.

FROM DREAM TO REALITY: THE PEOPLE MAKING IT HAPPEN

FET projects are full of great science, fantastic visions, novel concepts. These remain just ideas if they are not with the right people taking them forward. FET attracts also the kind of people that can make the difference. They help to create the mind-set and the conditions to bring these great ideas alive - out of the lab and into the real world. Starlab co-founder and Neuroelectrics CEO Anna Maiques, for instance, was one of the three 2015 Women Innovator laureates (see HIVE). Silvestro Micera started as a researcher in the FET project CYBERHAND project in 2002, but then consistently took the vision of a cybernetic prosthetic hand forward all the way through successive FET projects, to the point of a successful trial with a real amputee patient, more than a decade later (see NEBIAS). But also small companies like Intrinsic ID (see PUFFIN) and InSphero (see Body-on-Chip) have strategically used FET project as stepping stones to stay on top in the new markets they are creating, witnessed by the innovation awards and recognition they get – not to mention their top-notch global client base of chip-makers and big-pharma, respectively. FET is also about 'making it happen'.



FET research frontiers in Robotics

FET projects are pushing the science and engineering of robots beyond fiction. Robots inspired by plants, octopus or insects. Swarms of robots with emergent collective behaviours, evolving and shape-changing robots. Wearable robots, robots with a sense of time or with humour. These are some of the topics explored.

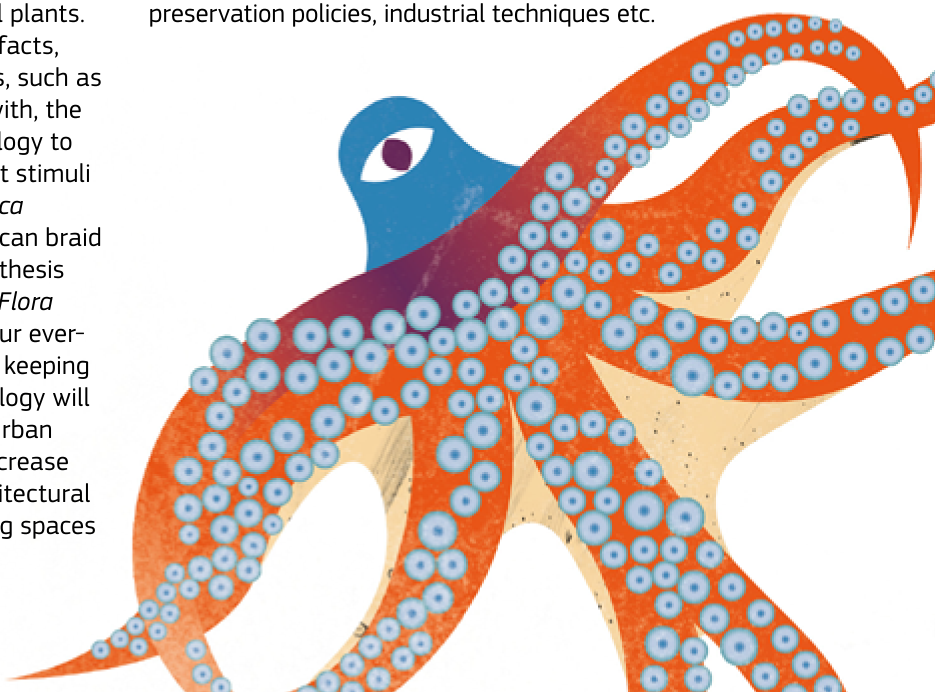
BIOMOT – Wearable robots are programmable body-worn devices, or exoskeletons, designed to assist or even substitute human motor function for people who have severe difficulty moving or walking. For BIOMOT, such wearable equipment should be more compact and lightweight, and better in anticipating and detecting the intended movements of the wearer. The wearable robots must also be more versatile and adaptable to help people in different situations; walking on uneven ground, for example, or approaching an obstacle. To address these challenges, BIOMOT created remarkable robots with real-time adaptability and flexibility coming from an improved symbiosis between the robot and the user through dynamic sensorimotor interactions. Even better, the exoskeleton can be personalised to an individual user.

PLANTOID-. Humans naturally understand problems and solutions from an animal's perspective, tending to see plants as passive organisms that don't 'do' much of anything, but plants do move, and they sense, and they do so in extremely efficient ways. Inspired by the plants themselves, how their roots penetrate the grounds, explore and adapt, PLANTOID builds innovative robotic artefacts. The first prototype includes two functional roots, one embodying artificial growth and penetrating the soil by an additive process of material; the other root implementing bending capabilities in three directions: the sensory systems for temperature, humidity, gravity and touch, and the electronics required for sensor conditioning and actuation control. The two roots are integrated in a trunk containing a microcontroller main board with communication capability. The branches of the trunk integrate artificial leaves made with materials that "respond" to environmental changing conditions (e.g. humidity and temperature). This result is a prelude to more complex studies on the hierarchical structure of the plant cell walls. PLANTOID is the first to design and develop robotic solutions based on plant models. The prototype is not meant to serve a particular application as such, but represents a demonstration of new robotic techniques. Potential applications for such technologies can be seen in agriculture, medicine and even space exploration.

OCTOPUS - Its arms are soft and deformable, they can bend in any direction at any point along the arm; however, they can stiffen when needed and they can grasp and pull objects with considerable strength; the octopus does not have a large brain, yet it can control this huge range of possible movements and motion parameters. What are the secrets to the octopus's soft dexterity? The OCTOPUS project set a completely new research direction in robotics by building robots with soft materials. Biologists, roboticists, computer scientists and material scientists dived deep into the study of this fascinating marine creature and the key working principles of its dexterity and intelligence. The OCTOPUS robot is a soft-bodied 8-armed robot that can crawl in water and take objects with a stiff grasp. It is now little more than an exhibition of the feasibility of soft robots and related technologies, but it is already making its way towards helpful applications: a soft endoscope for biomedical applications, and a 'grown-up' octopus robot helping humans in underwater exploration and operations.

FLORA ROBOTICA – The *Flora Robotica* project brings nature and technology closely together. Distributed robot systems are used to steer the growth of natural plants. The underlying idea is to grow architectural artifacts, that is, forms and shapes with desired functions, such as green walls, benches, or even houses. To start with, the project has developed a completely new technology to autonomously control natural plants by different stimuli (e.g., light, vibrations). For example, F*lora Robotica* robots can detect the presence of a plant, they can braid scaffolds for plants, and monitor their photosynthesis activity and sap flow. With this new technology *Flora Robotica* will address the future challenges of our ever-growing cities, helping to make them green and keeping townspeople in touch with nature. The methodology will help to popularize trends, such as vertical and urban gardening. The automation of gardening will decrease the costs for green infrastructure and new architectural approaches will help to advance designs of living spaces and houses.

subCULTron **-** The waters of Venice are challenging for underwater robotics due to their currents, their turbidity, and the high fragmentation of the habitat. subCULTron **developed** a society of more than 120 robots that will inhabit the Venice lagoon. The autonomous underwater robotic society comprises three swarms of bio-inspired robots that monitor the environment in a marine habitat. This largest autonomous underwater swarm in the world will collect environmental data and help in conservation of this precious world heritage. The subCULTron project has designed 3 different bio-inspired robot species: an aPad robot floating on the water surface, an aFish swimming in shallow waters and an aMussel robot on the seabed. This swarm of robots adapts to its environment and collects environmental monitoring data from the underwater habitat over longer time spans. The aMussel robots collect and store data, the aFish transports this data and the aPad brings the information to the surface. Apart from contributing to the scientific community by developing novel bio-inspired behaviours and implementing a real world application of a robotic swarm, the subCULTron system will also gather enormous amounts of environmental data which can be used to fine-tune nature preservation policies, industrial techniques etc.

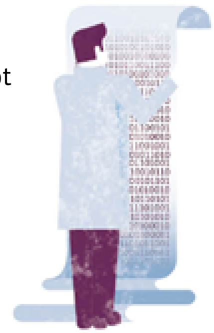


FET research frontiers in Information & Modelling

Information, knowledge and models are three steps along the way to understanding the weather, the physiology of diseases, or the economy. As systems become more and more complex we need better tools to capture the information, to extract the knowledge, to construct and to validate the models. Several FET projects are looking at privacy-preserving data collection, data mining, multi-level modelling, high-end simulation, and visual analytics, among other topics.

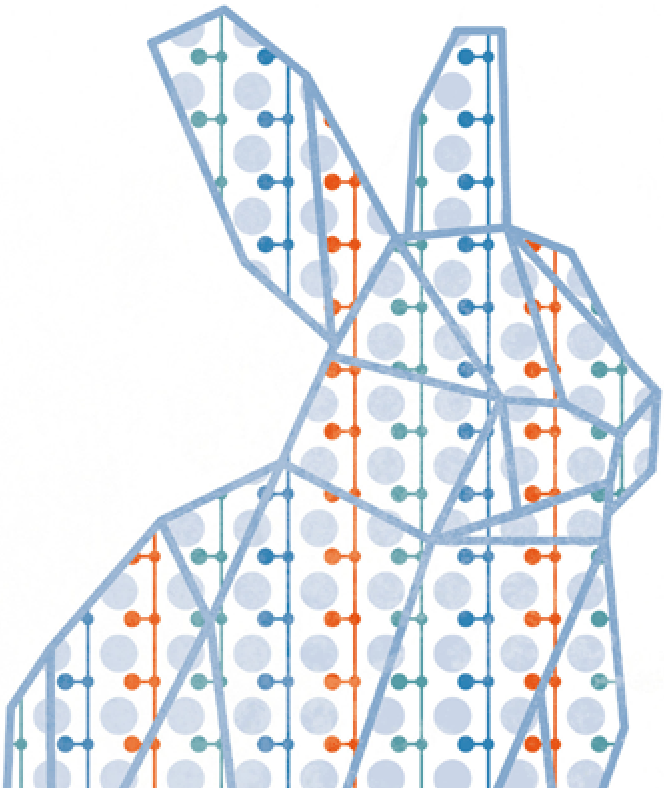
Harvest4D solves many fundamental problems related to the capture, reconstruction, and visualization of 3D data to create 4D models. Facing the challenges of huge amount of data, different modalities, varying scales, dynamic, noisy and colourful data, Harvest4D proposed a radical change: instead of a goal-driven acquisition that determines the devices and sensors, Harvest4D method let the sensors and resulting available data determine the acquisition process. The result is a method for remote navigation of complex archaeological 3D environments especially tailored for web visualization such as the Arènes de Lutèce or scans of the archaeological excavation site at Santa Marta. This is very relevant to the proliferation of visual data and the growing need for efficient yet accurate 3D reconstructions. The outcomes will contribute to the rapid, scalable analysis of streaming data, the detection of changes in appearance and geometry, and the reflectance reconstruction and 3D rendering (also for resource constrained devices). The innovative nature of Harvest4D will lead to the commercial exploitation of two of its modules: the Multi-Depth-Map Ray Tracing and the Contribution to Dome II Reflectance Acquisition Device.

INSIGHT - How do we solve problems? How are our ideas evolving in our brains? How has human language developed? Over the years we learn through experience and play how to walk, talk and socialise, while the development of complex, knowledge-expanding ideas such as Einstein's theory of relativity can take decades. Often a 'eureka' solution can pop into your head without prior warning, suggesting that unconscious processing plays a crucial role in insight. Supporting the Darwinian neurodynamics theory, INSIGHT used computer simulations, robots, examinations of cell cultures and human psychology experiments and neuroimaging to see how we think and what implications this could have on problem-solving robotics. Robots were fed natural selection algorithms designed to create open-ended creative autonomous exploration, and tested to see if they could, in effect, create their own objective. The impact of this research is far-reaching. One interesting twist might be that the evolutionary processes going on in the brain could even be more powerful than in the wild, as they are modified and guided by learning. While much of this remains speculative – and further refinement of models are required – this theory could one day lead to self-learning machines, smarter language translation and transform teaching and problem solving. The project led to the setting up of an open source platform to support the evolving robots (co-evolution of robot bodies and brains), called Robogen.



FET research frontiers in Biotechnologies

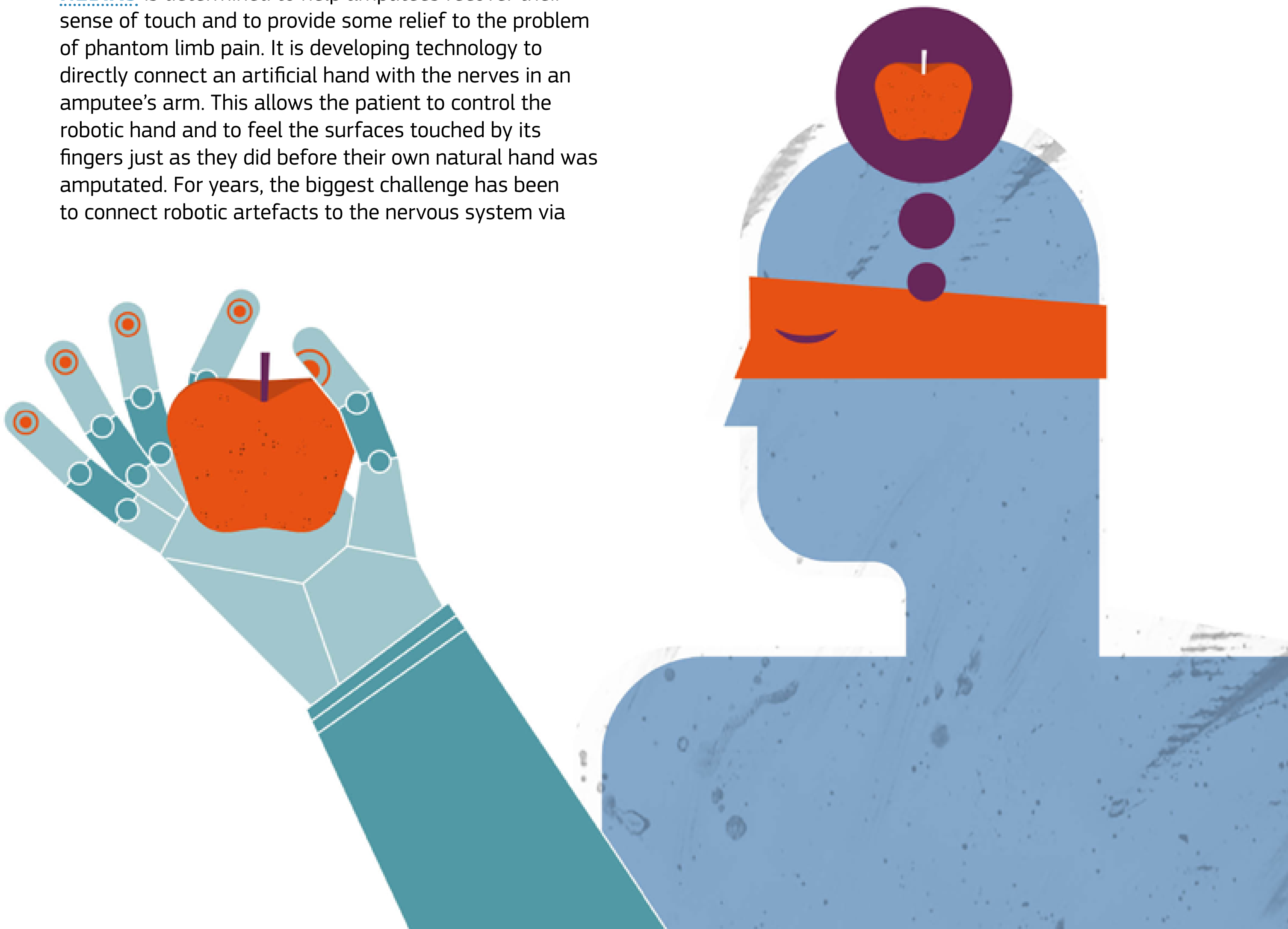
The convergence of biology, nanotechnology, neuroscience and information technology is interfacing wet and dry technologies. This convergence creates tools to better study one or the other, to create hybrids between them or to use inspiration from neuroscience and biology to create better systems (sensors for instance). Neuroprosthetics is an important area of application for this.



Body-on-Chip is a perfect example of how a FET project can take a small but thriving biotech-tech company to its next level of innovation, thus securing its leading position. Zurich-based InSphero is one of the main providers of 3D spherical tissue cultures for the pharmaceutical industry. Their core business relies on proprietary techniques to produce spheroid micro-tissues representative of human and animal organs such as the liver, brain or heart, in healthy as well as diseased variations.

When the project started in 2012 they were shipping their tissue-loaded plates to 5 of the top 10 pharmaceutical companies. Three years later they had all 15 of the top 15 pharma's worldwide as client. Companies like these are making a difference, and FET is helping them to go even further. Thanks to this project, InSphero could work with the best teams in Europe to acquire the know-how for producing and delivering microfluidic technology that replaces the 2D cell culture conventionally used for drugs testing with a multi-tissue device that better mimics real-life conditions in the body, by combining several organ-specific 3D cultures into a single chip through which drugs and nutrients are flowing. This brings toxicology and effectiveness testing of candidate drugs, which is one of the most expensive phases in drug discovery, much closer to the conditions in a real metabolic system of a biological body. Other firms are working on this, with budgets orders of magnitude larger than what was available for this project. Yet, the small company – like David against Goliath - and its partners were able to make convincing progress, witnessed by prestigious features in scientific journals such as Nature. And – small is not only beautiful but also fast – InSphero could commercialise the technology as soon as 2018.

NEBIAS is determined to help amputees recover their sense of touch and to provide some relief to the problem of phantom limb pain. It is developing technology to directly connect an artificial hand with the nerves in an amputee's arm. This allows the patient to control the robotic hand and to feel the surfaces touched by its fingers just as they did before their own natural hand was amputated. For years, the biggest challenge has been to connect robotic artefacts to the nervous system via electrodes implanted into a patient's nerve. The sensory feedback challenge was overcome only recently, and NEBIAS is now fully exploiting the prosthesis and further developing the technology to bionic arms. A prosthetic hand, which provides a sense of touch acute enough to handle an egg, has been completed and was tested with the help of amputee Dennis Aabo Sørensen who was able to grasp objects intuitively and identify what he was touching, while blindfolded.



From the lab to the patient

NEBIAS' achievements are the most recent steps, culminating advances from several projects. The idea of the bionic hand started within the FET project CYBERHAND, some 13 years ago. Another FET-project, NEUROBOTICS, developed key parts of the technology to interface with the peripheral nervous system. National funding from Italy was used to involve surgeons and prepare the clinical trial. Over these different EU funded projects, scientists from 29 different institutions, involving 7 EU countries (and a participation from USA) worked together with just one goal – to make a prosthetic hand that can enable natural sensation and motion. It is the pursuit of a vision through successive projects that allows to overcome the various challenges, resulting in ground breaking innovation that may well enhance the lives of amputees like Dennis.

FET RESEARCH FRONTIERS IN COMPLEXITY SCIENCE

When many simple systems start to interact, anything can happen. In complex systems, even if the local interactions between the various components may be simple, the overall behaviour is difficult and sometimes impossible to predict, and novel properties may emerge. Understanding this kind of complexity is helping to study and understand many different phenomena, from financial crises, global epidemics, propagation of news, connectivity of the internet, animal behaviour, and even the growth and evolution of cities and companies. Mathematical and computer-based models and simulations, often utilizing various techniques from statistical physics are at the heart of this approach.

EveryAware is your way to fresh air! Air and noise pollution are among the most insidious threats to our health. But what if we could monitor both from our smartphones? The AirProbe and Widenoise apps developed by EveryAware project have made this possible; AirProbe monitors exposure to air pollution and Widenoise measures noise levels. Both apps include social games to share information and impressions as well as interactive maps that help to increase people's awareness of their environment. People can measure air pollution wherever they are and view in real-time the air quality in their living area with mobile sensor boxes and via web interfaces. Not only will the apps help vulnerable people such as children, the elderly and asthma sufferers to make healthy choices, but they are also fun to use, making their uptake more likely. Scientists can also use the information gathered to analyse pollution trends and post this information online for city-dwellers and public authorities. This could serve, for example, for combating traffic congestion.

IBSEN - We are faced nowadays with complex problems such as climate change, financial instability, epidemics, and social inequality, to name just a very few. In addition, human society itself has become ever more complex with interactions taking place not face-to-face but digitally or virtually and on a large scale between culturally and geographically distant people. To tackle complex societal issues, policy makers need accurate, quantitative predictions of human behaviour and interaction based on controlled experimentation with large groups of people. Deeply rooted in the emerging field of computational social science, IBSEN is developing a global societal simulator with a potentially huge impact on research and policymaking. The approach will yield both explanatory and predictive models from large-scale experiments (1000+ participants) and their resulting massive ICT data. This will not only allow to study and predict human behaviour under real word conditions but also to gain insights on phenomena that only arise in large-scale groups and therefore do not feature in current experimental set-ups.

FET equals deep interdisciplinarity

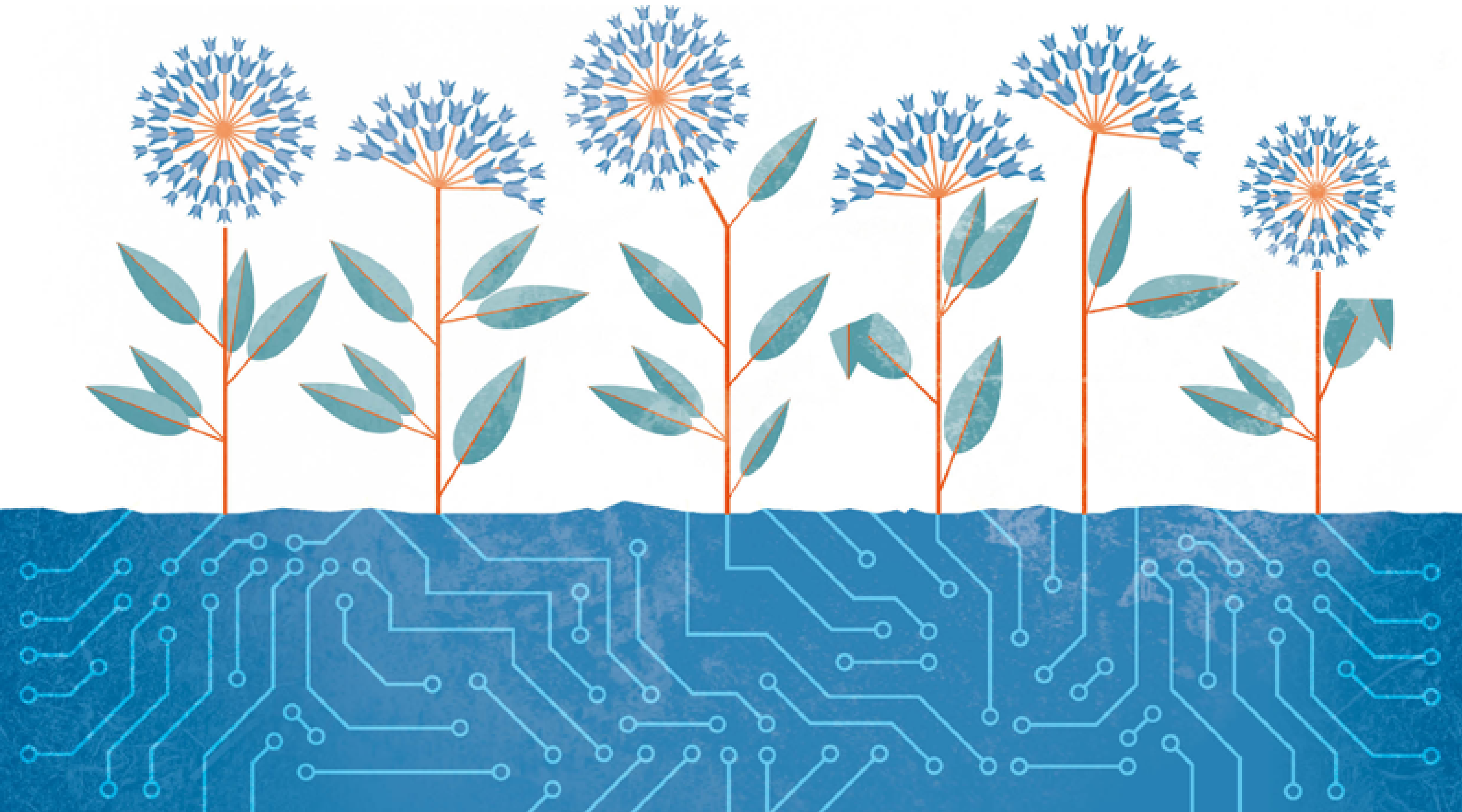
Collaborative research and a deep interdisciplinarity are inherent to FET. It's all about questioning the fundamentals of the world, learn and exchange, deconstruct to better construct and ultimately build new synergies.

For instance, one thing is to build a cellular automaton in software, another is to build a computing device with real biological cells. Everything the computer scientist knows about programming, algorithms, data structures, and so on would have to be questioned. And the biologist would have to make sense of cell interactions in terms of information exchange rather than chemistry. But if it works, the computer scientist will think differently about computing, and the biologist will think differently about cells.

FET is rich in examples of interdisciplinarity. The projects SWARM-ORGAN, PLANTOID and PLEASED use plant biology in different ways for future technology research: the first one for swarm-robotics inspired by cellular level morpho-genesis in plant roots; the second one by mimicking root developments in a plant-like artefact; and the last one by using plants as sensors for pollutants. BACTOCOM, EVOPROG, PLASWIRES and ABACUS try to use real bacteria for computing or for communication, while projects like NEUNEU, BIOMICS, ECCELL or RIBONETS take cellular processes as a basis to achieve the same. New techniques for self-assembly and self-organisation of computing devices and networks can be gleaned from chemistry, ecology, neuroscience or (cell-) biology as pioneered in projects like BION, 3DNEURON, BRAINBOW, EFLUX, SECO, NASCENCE, ASSISI_BF or the support actions INBIOSA and more generally the Convergent Science Network. Many projects are developing neuro- or bio-morphic devices like artificial eyes (EMORPH, CURVACE, SEEBETTER, RENVISION, VISUALISE) and other sensors (NEUROCHEM), prostheses (EVRYON, OPTONEURO, CLONS, RENACHIP, BRAINBOW, ENLIGHTENMENT, CORTICONIC, NEBIAS) and entire brain-like computers (SI ELEGANS, BRAINSCALES, BRAIN-I-NETS).

It is through such mind-stretching collaborations that FET projects push the boundaries of technology and offer radically new possibilities for multiple sciences and industry sectors beyond ICT. For example: BOC and CADMAD for the pharmaceutical industry, EPIWORK and DYNANETS for epidemiology, SAGE for evolutionary biology, NEUROSEEKER, BRAINLEAP, CONNECT, HIVE, HBP and 3x3D IMAGING for neuroscience, FOC and NESS (CSA) for finance and economics, HELICOID in oncology, LIQUIDPUBLICATION and BS4ICTRSRCH (CSA) in publishing, MD and INSITE (CSA) for innovation management, COSIT in non-destructive material testing, UnLocX in medical imaging, SKAT-VG and URBANIXD in design, SUMO in climate modelling.

The deep synergistic interdisciplinarity of FET breeds a new kind of researcher that can bridge into the terminologies and methodologies of other fields. The permeability of disciplinary boundaries changes how a researcher looks at her or his own discipline. More so, such a researcher is not be afraid to question the fundamentals of her or his own field to try to understand how others look at it. This works particularly well when teams do not share the same framework of assumptions that many of the “harder” science and engineering disciplines have (more or less) in common. This dissonance is at the heart of the interdisciplinarity that FET is looking for. For sure, this requires excellence in one’s own discipline if the obligatory ‘deconstruction’ is not to be fatal or, at least, entirely demotivating. But if it works, it can change your life.



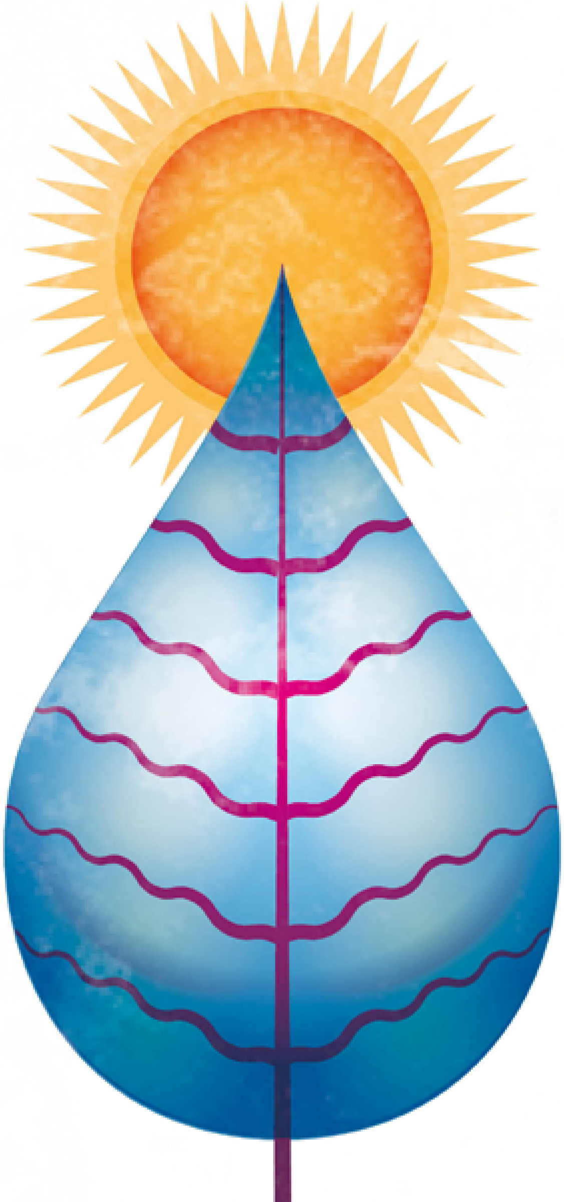
FET research frontiers in Computer Science

Computers are everywhere but is computer science ready for this? This is the challenge for FET projects that are pushing information theory, algorithmics, signal processing, communication protocols, cryptography and other core areas of computer science to a new level of ambition where the high expectations can really be met.

PUFFIN - Strong and reliable authentication is key in our digital society. The existence of Physical Unclonable Functions (PUFs), the technology that implements the electronic fingerprint of devices, has been demonstrated by the PUFFIN FET project in standard devices. The applications for mobile phones, smartcards and Internet of Things (among others) are now implemented by its SME partner Intrinsic-ID. This company had already developed a robust PUF technology (called Hardware Intrinsic Security, HIS) for specialized devices, thanks to its involvement in a previous FET project, UNIQUE, where it could work with the best European teams to prove its unique approach to forgery-resistant hardware security. The objective of the FET high-tech SME project PUFFIN, where Intrinsic-ID was the SSME partner, was to further demonstrate the existence of PUFs in standard PCs, laptops, mobile phones and other consumer electronic devices. The results demonstrated, theoretically and practically, that these PUFs are very suitable as a root of trust for mobile devices. On top of that, they can be used for the generation and management of strong keys and passwords. Since the technology is very low cost to implement, it has the potential to replace current technologies (such as Trusted Platform Modules, TPMs) in several use cases. Intrinsic-ID won the Innovation Radar Prize in 2016 for their revolutionary PUF technology.

ODYCCEUS - Social media and the digitisation of news and discussion fora are having far-reaching effects on the way individuals and communities communicate, organise, and express themselves. The information circulating on these platforms can be used to understand, monitor and maybe even resolve the growing number of social crises due to cultural differences and diverging world-views. More specifically, ODYCCEUS tries to pinpoint the social crises in the Euro-Mediterranean public arena, their causes and possible solutions before they break into open conflicts and violence. The project will develop an open modular platform, Penelope, based on complexity system science that integrates data from social media and digitalized news and allows for citizen participation in the visualisation of the analyses and models developed by the project. The project will also build two innovative participatory tools, the Opinion Observatory and the Opinion Facilitator, which allow citizens to monitor, visualise and influence the dynamics of conflict situations that involve heterogeneous cultural biases and non-transparent entanglements of multilateral interests. Hopefully, their tool will help anticipate conflict and solve it before it leads to violence.

FET research frontiers in Green technologies



Energy consumption is one of the biggest hurdles towards achieving green computing and networking. A growing number of projects are tackling this problem head on. Topics addressed range from new ways of green power generation, over energy aware computing, to challenging the famous Landauer limits of how efficient computing can be in the first place.

A-LEAF - Our society has been using fossil fuels as a primary source of energy and as raw materials for synthesising complex organic compounds with added value such as drugs, polymers or agrochemicals. A-LEAF seeks to respond to the world's challenge of finding new sustainable alternatives to fossil fuels by developing technology to directly harvest solar energy for the production of chemical fuels. Building a device able to mimic this photosynthetic process as carried out by green plants, A-LEAF aims to achieve direct transformation of water and CO2, through the action of sunlight, into oxygen and organic matter (e.g. methanol, methane). A photo-electro-catalytic cell which will combine sunlight, water and carbon dioxide with the aim of producing carbon based liquid fuels, and oxygen as a by-product. This work represents the first step towards positioning such "artificial leaves" as a source of sustainable fuel to replace the fossil fuels currently used for power generation.

FET research frontiers in Medical Technologies

Numerous are the projects that explore new technological possibilities in medicine and therapy. Why, for instance, use conventional drugs when also electrical stimulation can help to cure? How to recover sight or the sense of balance after eyes or vestibular systems degraded from aging or trauma? How to study and influence brain processes that are at the basis of, for instance, Alzheimer or Epilepsy? We think for example about new imaging technologies, DNA sequencing and analysis, technologies for targeting drug release or cell destruction.

RENVISION - Understanding the neurobiological principles of seeing - beyond the functioning of the eye and retina alone – can help developing artificial computer vision, and therefore equip robots with vision capability, perform pattern recognition tasks with a computer, or even help impaired people. RENVISION developed and exploited a novel experimental platform for simultaneous visual stimulation, electrical recording of retina cells activity and high resolution imaging of the whole retina. This platform is a first step for a better understanding of the retina complex functions. The project also developed computational tools (open source) which can be further used by the neuroscience community for analysis of neuron activity or simulation of neural networks. The project could therefore solve some of the most difficult tasks in computer vision - such as automated scene categorisation and human action recognition - so that robots and computers can see and perceive what is happening in the images they receive.

CResPace will pioneer disruptive technology for bio-electronic medicine to provide much-needed therapies for cardiorespiratory and functional neurological disease. The project uses physical models capable of predicting neuron behaviour and small neural devices which have proved effective in reversing the effects of heart failure. These will give us therapies for chronic cardiorespiratory disease including cardiac arrhythmias, heart failure, extending patients' lifespans and improving quality of life. The technology uses small neural networks known as central pattern generators (CPG) to deliver fit-and-forget bio-electronic implants that respond to physiological feedback in real time, are safer, simpler, non-invasive, and will last a lifetime. By designing a pacemaker using technology mimicking neurons, the pacemakers will be able to respond to inputs much more realistically and appropriately for the patient.

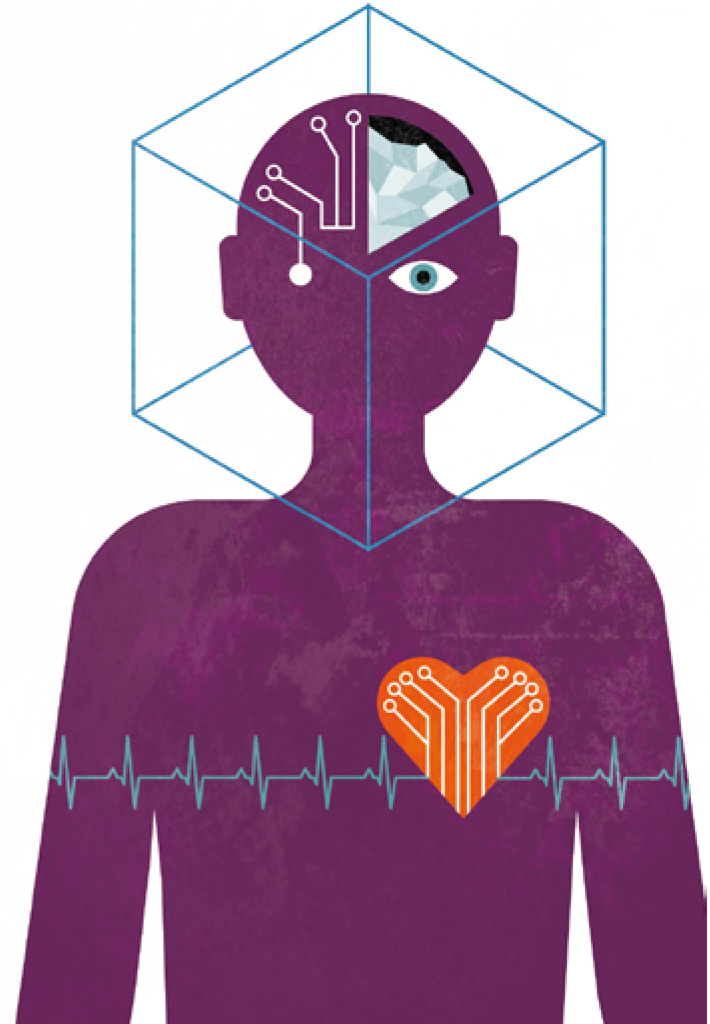
FET EXCELLENCE IN SCIENCE

FET has seen the participation of no less than 10 Nobel Prize winners in Physics, Medicine and Chemistry, 7 of which received the prize after having been in FET. The turn-out of scientific publications from FET research is also very high.

In the recently finished project iQuoems, 6 partners from 6 countries collaborated for 3 years on "Interfacing Quantum Optical, Electrical, and Mechanical Systems". Of the 59 project publications, 17 are in high-impact journals including Nature, Nature Communications, Physical Review Letters, Physical Review X, Applied Physics Letters, Proceedings of the National Academy of Sciences. In the course of this project researchers have delivered 153 invited lectures and seminars at international conferences, workshops and colloquia. iQUOEMS researchers have been awarded 9 prestigious national and international Prizes and Awards within the duration of the project. Projects like this also train the next generations of researchers with an estimate of the young researchers involved of around 20 Phd students and 15 postdoc.

For many who went through the FET experience, the excitement of the visionary interdisciplinary collaborations in FET has been addictive, leading to a new orientation in their careers. A survey among FET participants indicates that for 31% of them, branching out into new areas of research was the primary positive effect on their research career. Additionally, almost 90% of respondents see their FET project as positive for their career, with benefits in international networking, learning from other disciplines and the opportunity to do far-reaching research.

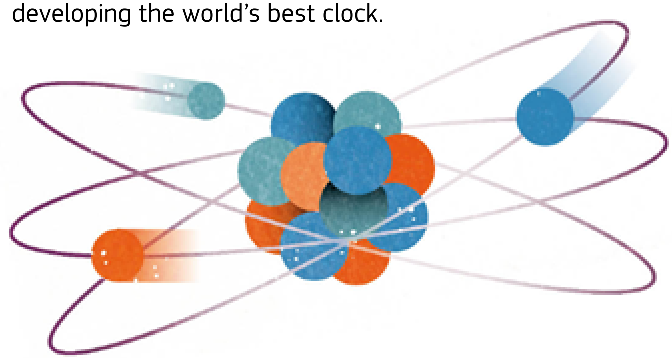
VOXEL explores a revolutionary alternative to conventional X-ray tomography. The project aims at developing a ground-breaking 3D X-ray technology which not only will bring important reduction of the classical tomography's adverse side effects (e.g. harmful ionizing irradiation), but also a great improvement of the quality of images (e.g. nanometre spatial resolution) with much more information impacting quicker and better diagnosis. The technology will have important impacts on image acquisition related applications going from general microscopy, medicine, microbiology to material science and beyond.



FET research frontiers in Quantum Technologies

The increasing ability to manipulate quantum effects is leading to devices with fundamentally superior performance and capabilities for communication, metrology, sensing, simulation and computing. Data security and safety will also be dramatically impacted by quantum technologies. Therefore, mastering quantum technologies is of strategic importance for a Digital Single Market in Europe. But Quantum is relevant beyond 'cold' technology, as illustrated by the emerging field of Quantum Biology. After all, in a way quantum is everywhere!

nuClock - Since ancient times, mankind has been concerned with the measurement of time: just think of the old Mayan calendar. Each technological innovation brought about an immediate benefit for society. Understanding the movement of celestial bodies enabled ancient farmers to define the right time for harvesting. Mechanical clocks revolutionized navigation on the sea, while quartz clocks later allowed anyone to wear a watch that is accurate to within a few seconds in a year. Today, atomic clocks on board satellites provide the GPS signals that we use every day in satellite navigation, telecommunications, high-speed mobile networks and even banks. nuClock's ambitious goal is nothing less than to build the most precise clock in the world. Since their invention, atomic clocks have been constantly improved, achieving today 100 times more precise results. nuClock proposes a much higher precision compared to today's best atomic clocks. The NuClock project's radical approach is to shift measurement from the atomic level to the quantum states of the atomic nucleus. Here the difference between two energy levels used for time measurement is larger than that in the atom. NuClock's success is a major step towards developing the world's best clock.



From MINOS to HOT. Early computers were using mechanical relays as switches. Future systems may well use nano-opto-mechanical devices. These rely on light-matter interaction to control the mechanical vibrations of tiny mirrors in small cavities. When properly done, this cools down the systems close to their mechanical quantum ground state, where they can be used to store information, or to interface with signals encoded as light, in microwaves or electrically. This may well be the missing link to connect quantum computers to quantum networks. This bi-directional conversion between different kinds of signals was the core objective of the FET project iQuoems (see box). Almost ten years ago the FET project MINOS was the first to put this topic firmly on the map of future and emerging technologies, and to establish its global reputation with several 'first ever' results. Thanks to this, Europe has taken the lead in this area which is now proliferating in various directions, for instance for efficient signal conversion with minimal noise, to integrate multiple modalities (optical, RF, mechanical) into hybrid metamaterials, to reach signal interactions with ultra-high frequencies and bandwidths. The most recent addition to this line is the FET project HOT that is bridging from the hard science to industry (including CMOS integration) but also continues to push the frontiers, for instance by exploring opto-mechanical interactions at the molecular level.

QUANTUM TECHNOLOGIES: A FET SUCCESS STORY

FET has been pioneering Quantum Technologies since the 4th Framework Programme (FP4, 1994-1998). The first research roadmap for this area was published in 1999, as a result of the FET funded Pathfinder project. In the 5th Framework Programme (FP5, 1998-2002) FET launched the first proactive initiative on the topic, 2 years before DARPA's first quantum initiative. Over more than 20 years, FET has made a total investment reaching ~250M€ in EU funding. Investment from FET has steadily increased over time, reaching 94M€ in FP7 (2007-2013) and demonstrating an increasing interest in the topic among the research community. Research projects have covered a wide variety of quantum technologies, including novel sensors, quantum key distribution (QKD) and qubits. A number of FET coordination and support actions have further contributed to establish a world class European research community in Quantum Technologies.

In 2016, a large number of European countries have launched QuantEra, an ERA-NET Co-fund initiative in Quantum Technologies under the FET programme. Thanks to a joint dynamics from the research community, member states and industry, a broadly supported Quantum Manifesto was issued "to put Europe at the front of the second quantum revolution now unfolding worldwide, bringing transformative advances to science, industry, and society."

A large scale FET-Flagship initiative on Quantum Technologies will be launched in 2018. This would have been impossible without the continued support from FET-Open and FET-Proactive initiatives.

PAPETS – Could quantum physics explain phenomena in biology, like photosynthesis or olfaction? The FET project PAPETS ("*Phonon-Assisted Processes for Energy Transfer and Sensing*") is answering this question. In FET's best multi-disciplinary tradition, it explores quantum biology, the newly emerging area between biology and quantum physics, to determine the role of coherent vibrational dynamics in the efficiency of energy storage in natural and artificial light harvesting systems, as well as in odour recognition. The fundamental understanding of how photosynthesis works could result in the design of much more efficient solar cells. Olfaction is another promising area: unlike seeing, hearing or touching, the sense of smell is difficult to reproduce artificially with high efficacy. Research indicated that the quantum tunnelling of electrons associated to the internal vibrations of a molecule may be a signature of odour. This work could have applications in the food, water, cosmetics or drugs industries. Better artificial odour sensing could be used to detect impurities or pollution, for example.

FET Research frontiers in Neuroscience & the Human Brain Project FET-Flagship

Understanding the brain is one of the big scientific challenges of humanity. Many FET projects are tackling aspects of it, in many different ways. The resulting synergies between technology and neuroscience are amazing. Neuroscience is advancing more rapidly thanks to new computational and experimental tools. New models and theories can be tested in advanced simulations that were not possible only a few years ago. But also new forms of computing become possible in brain-like hardware and brain-inspired algorithms are able to tackle hard problems in ways that match or surpass human performance.

HIVE started from the idea that one day it would be possible for brains to communicate directly with each other. While there has been considerable progress in getting information out of the brain, less is known about how to get information into it. The project performed a series of developments and experiments for non-invasive brain stimulation to test the possibility of doing just that - getting information into the brain. In the end it managed to perform an integrated experiment that demonstrates computer-mediated communication between two remote brains, without use of the normal sensory apparatus. HIVE was particularly interesting because of its coordinator, Starlab, a small high-tech Barcelona based company. Thanks to HIVE it could team up with the best expertise in Europe to do world-class research that would give it the network, credibility and expertise for the next step. As a result of HIVE the company created a new spin-off called Neuroelectrics to commercialise its brain-to-machine and machine-to-brain technologies. A next project, called LUMINOUS, is further exploring the possibilities of using the technology to study and alter states of consciousness. This has resulted, for instance, in first-ever communication with so called locked-in patients. At the same time the company is running a clinical trial to control epileptic seizures in young children, using their technology.

The Human Brain Project is one of the Future & Emerging Technologies (FET) Flagships of the European Commission launched in 2013 to provide researchers worldwide with ICT tools and mathematical models for sharing and analysing large brain data they need for understanding the brain, its diseases and its capabilities. The HBP has the potential to revolutionise the future of neuroscience, medicine, and computing. An important milestone was the first release of the HBP›s six ICT Platforms, providing a wide range of collaborative tools.

In many areas of science and engineering, simulation has proven an invaluable tool for turning mathematical principles, theory and data into new insights. Following the first computer reconstruction of a fragment of a rat neocortex (published in 2015), simulation is now applied to the hippocampus, the basal ganglia and the cerebellum before expanding it further. In parallel, work on system and cognitive neuroscience is contributing to the development of the different neuro-robotics facilities of the project.

A strong neuro-informatics services facility will use a new European federated computing and data storage/analysis capacity and provide a comprehensive use-case for the European Open Science Cloud. Technology investigations with manufacturers have resulted in the two impressive prototypes of interactive supercomputing, JULIA and JURON, needed by neuroscientists for simulating large brains models. Brain-inspired computing technologies which mimic spiking neurons have been integrated in two large "neuromorphic" systems featuring in particular plasticity and learning capabilities. Distributed analyses of electronic health records, brain and omics-data have allowed identifying new subtypes of dementia and first biological signatures for prognosis. HBP involves more than 400 researchers from 24 countries from all over Europe. Addressing brain diseases is a global challenge and HBP has established international cooperation with large-scale government-funded efforts, in particular the U.S. BRAIN Initiative, Japan's Brain/MINDS project, a Canadian initiative and with foundations such as the Allen Institute for Brain Science. Responsible research and innovation is receiving strong attention with both ethics management and foresight investigations.

FET research frontiers in Nanotechnologies

Nanotechnologies, science and technology at the nanoscale of atoms and molecules, will (ironically) help address key societal challenges on a large scale such as climate change, reducing carbon emission, developing renewable energies, and a more efficient use of resources. Activities addressing this challenge implement the next steps towards the deployment and market introduction of lightweight, multifunctional, economical and environmentally-friendly nano-enabled products for different applications, by scaling up laboratory experiments to industrial scale and by demonstrating the viability of a variety of manufacturing technologies.

2D-INK - The transition from fossil fuels to renewable energy, combined with the increasing power of today's portable devices, calls for cheap materials that can store electricity on an unprecedented scale. Researchers are exploring the extraordinary characteristics of two-dimensional nanomaterials to achieve this goal. 2D-INK aims at developing inks of novel 2D semiconducting materials for low-cost large-area fabrication processes. This will provide the key parameters for fabricating the next generation of ultrathin electronic appliances. The main achievement of the project during its first year is the preparation of different model precursors and covalent organic framework materials to test the most suitable approaches for their synthesis and has been developed for the characterization of 2D materials.

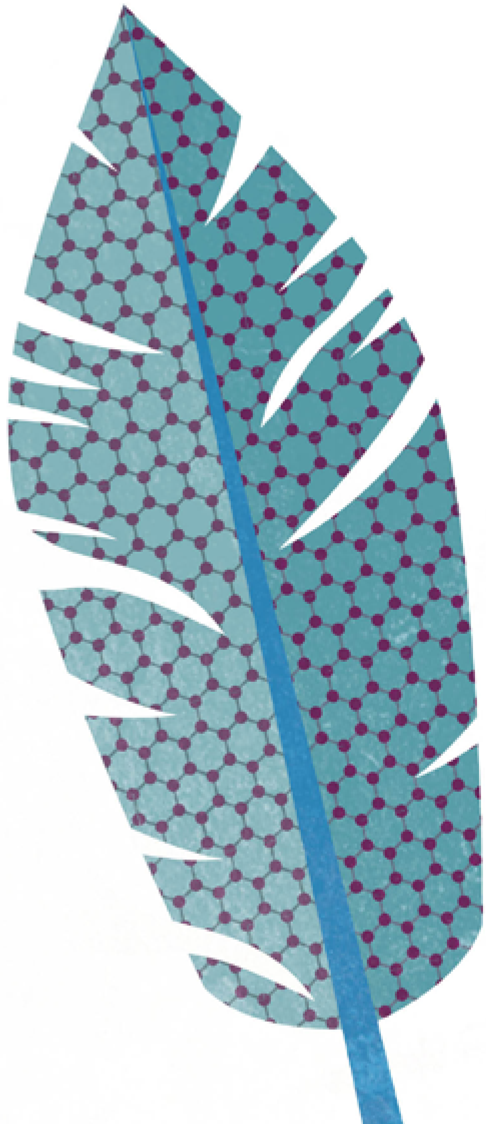
MAGicSky - FET-Open project MAGicSky is neither about magic, nor about looking at the stars. Its very down-to-earth objective is to significantly improve information storage capacity and the speed of information processing. MAGicSky research aims at developing extremely small and powerful memory elements. Current data storage devices use the charge of electrons to store and transfer information. Besides the charge though, electrons also have a spin, and this is exploited in the field of spintronics, the combination of spin electronics. The final goal of MAGicSky to manipulate specific configurations of atomic spins in metals, called skyrmions, in devices at room-temperature. The properties of the skyrmions will support the creation of next generation very high density information storage, breaking the barriers set by current technology. The main achievement of the project during its first year is the demonstration of room-temperature skyrmions in magnetic multi-layers.

FET research frontiers in New materials & the Graphene FET Flagship

The next-generation of materials include super-light materials and active materials that react to changes in their environment. Smart materials can "explain" how they are doing and can be significantly changed in a controlled fashion by external stimuli, such as stress, temperature, moisture, pH, electric or magnetic fields.

ABIOMATER is exploring how magnetically controlled metamaterials – engineered materials with properties not found in nature – could be used to improve medical devices and implants, from lenses to tissue engineering, upgrading treatment options for patients. ABIOMATER is harnessing magnetic and elastic forces on a microscale for the creation of novel types of active metamaterials. In the first year of the project the consortium created and successfully demonstrated a prototype of microbot, a microscopic magnetoelastic machine capable of self-propelling in liquids at low Reynolds number. Already at this stage, such devices can be used for implementing a range of microfluidic devices such as pumps, valves, and stirrers, directly integrated in microfluidic chips. But what it will bring to society? These microbots are of great importance in medical diagnostics, lab-on-a-chip technology and biomedical applications. The main advantage of such magnetoelastic systems is also in the fact that these are being produced by standard lithographic techniques, which are routinely used in fabrication technologies. This means that the systems can be easily scaled for mass production, thus providing a viable route for manufacturing of cheap and disposable products.

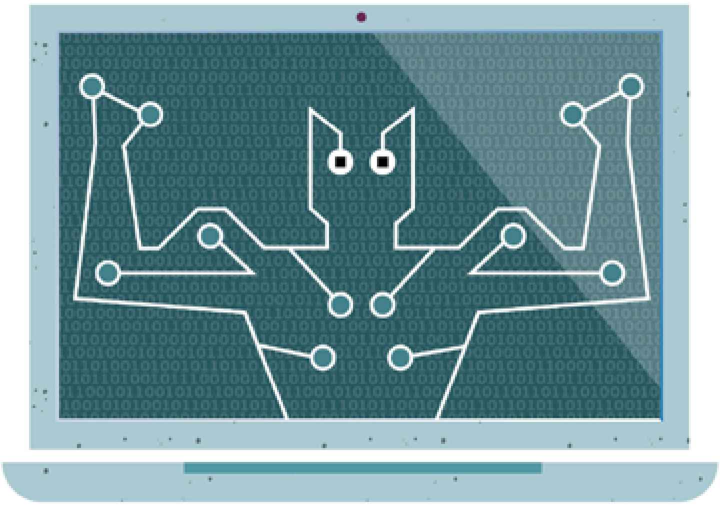
SimpleSkin - Body-borne sensors, so-called "wearables" are becoming part of our everyday life in the form of fitness bracelets and smart watches. SimpleSkin pushes innovation further by developing intelligent training clothing that measures breathing, muscle tension, balance and pulse and gives feedback on the physical performance and correct execution of sports exercises. Several other ambient technologies have been trialled successfully, including a smart tablecloth and an intelligent exercise mat that analyses the user's movements through pressure sensors, while several more, such as a pillow that detects people's sleeping posture, are currently under development. Through the integration of electrical sensing modalities into fabrics during the production process, it is now possible to mass produce "sensing enabled" textiles, which can easily be integrated into clothing production processes. These achievements will open the door to industrial manufacturing of smart clothing. The developed hardware platform connects to the smart textiles and generates electrical signals that can be analysed with the wearable computing applications. An Android-based “operating system” maximises the potential of widespread uptake and future development.



The Graphene Flagship launched in 2013, ambitions to take graphene and other related materials from the realm of academic laboratories to the European society, while stimulating economic growth and creating jobs. Graphene is a revolutionary carbon-based 2D material with extraordinary physical and technical properties: it is the thinnest material, it conducts electricity better than silicon, it is stronger than steel and has unique optical properties. The Graphene Flagship’s research effort covers the entire value chain, from materials production to components and system integration, and aims at developing applications in areas such as flexible electronics, printed electronics, 5G mobile technologies, batteries, aerospace, medical applications, filtration and automotive. A recent remarkable breakthrough of the Flagship is the first fully functional microprocessor made from graphene-like materials that is a first step toward ultra-thin, flexible devices and holds promise for integrating computational power into everyday objects and surfaces. Another innovation with applications in medicine are the graphene-based neural probes to examine brain activity in high resolution, which can help to better understand diseases such as epilepsy and disorders that affect brain function and motor control, as well as to improve neuroprosthetics by enabling control of artificial limbs. Other promising first results of the Graphene Flagship research include large-area Perovskite-based solar cells for producing electrical power with high efficiency (due to enhanced lifetime and performance of large scale areas) and the development of ultrahigh sensitivity graphene infrared detectors to measure temperature with strong accuracy, which is key for applications in security screening (e.g., looking for hazardous substances). The Graphene Flagship represents a new form of joint research funded by FET over a period of ten years. It is one of Europe’s biggest ever research initiatives, with an academic-industrial consortium of more than 150 partners in over 20 European countries and with 18 partnering projects mostly funded by European national agencies.

FET research frontiers in High-Performance Computing

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. 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.



DEEP-ER - Exascale computing, in which a quintillion (1018) calculations can be performed every second, is expected to become the standard for supercomputers over the next few years. The DEEP-ER project offers an innovative European response to the challenge. By developing a novel, Exascale-enabling supercomputing architecture with a matching software stack and a set of optimised grand-challenge simulation, DEEP-ER addresses two significant computing challenges: highly scalable and efficient parallel I/O and system resiliency. Seven real-world High Performance Computing applications, from seismology to researching human exposure to electromagnetic fields, will demonstrate the usability, performance and resiliency of the DEEP-ER Prototype. The ultimate goal is to develop a novel HPC platform that is inspired by the requirements of, and is most beneficial for, a wide range of users.

MONT-BLANC - Within a few years from now, supercomputers are expected to reach Exaflops (1018 floating point operations per second) performance levels - but they will have to do so with limited power budgets and an increasing complexity both in hardware and software. Compute efficiency and energy efficiency are, more than ever, major concerns for future Exascale systems. Since October

2011, the aim of the MONT-BLANC project has been to design a new type of computer architecture capable of setting future global HPC standards, built from energy efficient solutions used in embedded and mobile devices. With the ambition of setting new HPC standards for the coming Exascale era, MONT-BLANC focuses on transferring some of this technology to supercomputers so that they can process more information, with the same power, in the same space, and for less money. A MONT-BLANC End-User Group has been created, consisting of representatives from various industries – automotive, energy, oil and gas, aerospace, pharmaceutical and financial – testing the various novel architectures produced by the project and providing feedback to the researchers.

THE EUROPEAN HPC DECLARATION

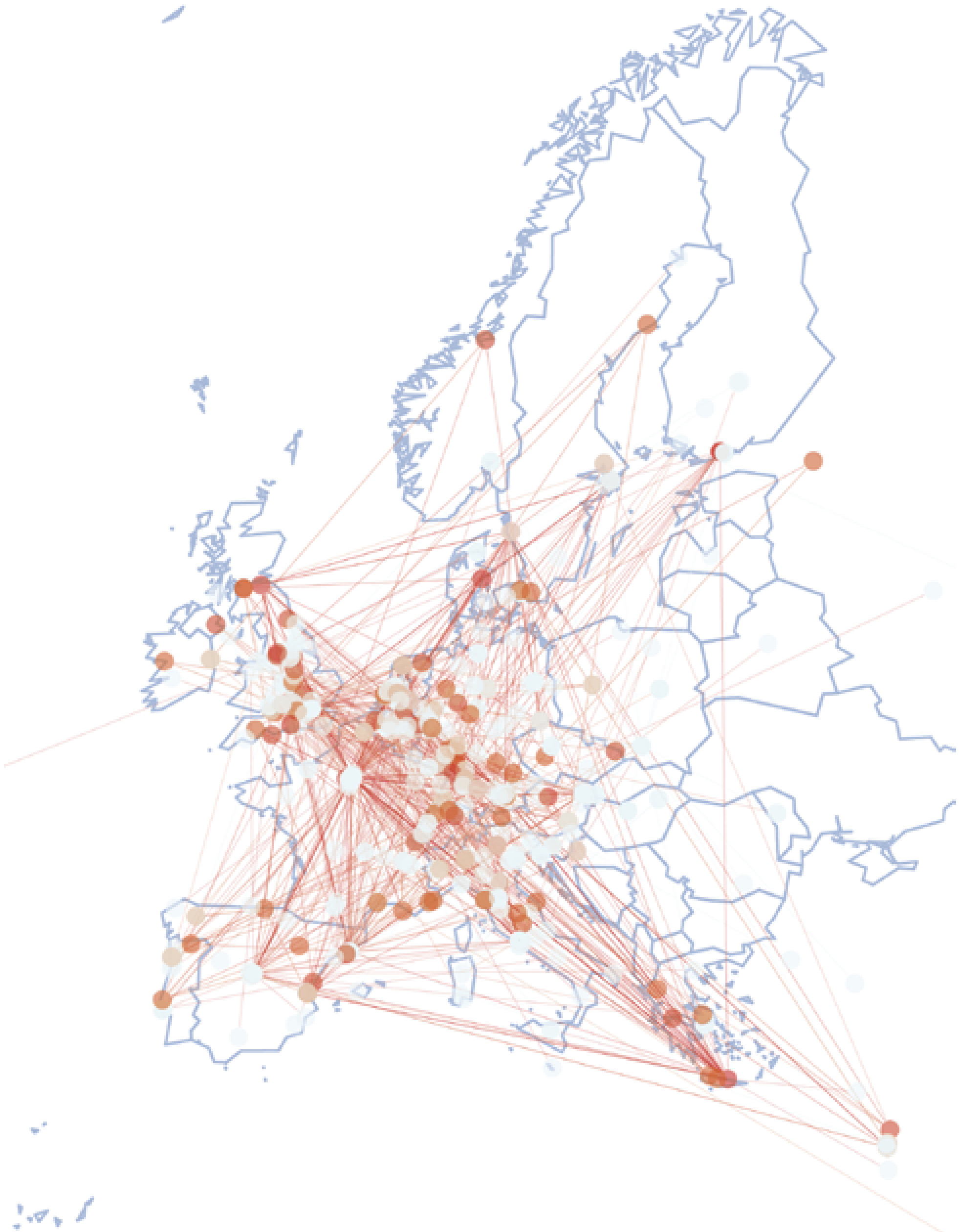
On 23rd March 2017, ministers from seven European countries (France, Germany, Italy, Luxembourg, Netherlands, Portugal and Spain) have signed in Rome a declaration to support the next generation of computing and data infrastructures, a European project of the size of Airbus in the 1990s and of Galileo in the 2000s. They plan to establish EuroHPC for acquiring and deploying an integrated world-class high-performance computing infrastructure capable of at least 1018 calculations per second (so-called exascale computers). This will be available across the EU for scientific communities, industry and the public sector, no matter where the users are located. More information is available here.

Art & Science and new ways of doing research

An increasing number of high-tech companies assert that scientific and technological skills alone are not sufficient anymore. In this context, the Arts are gaining prominence as catalysts for an efficient conversion of science and technology knowledge into novel products, services, and processes. FET has always been an early adopter for new ways of working across disciplines, pioneering for instance the collaboration between computer scientists, designers, anthropologists and other social scientists. Now also techniques like Flash mobs, speed writing, hackathons and a variety of participatory techniques are used to link science better to society, especially with the younger generations.

FEAT key objectives is to use artistic approaches to attract people from all levels and age groups in society to learn more about leading edge technological research and to increase the visibility and interest in FET research and results. Exchanges between FET projects and artists are an unprecedented element of innovation that will enable other FET projects to come into contact with the general public and focused groups of stakeholders, potentially providing a transformational impact on the connection between technological advances and (at least certain) sectors of society. Six leading international artists are hosted within Future and Emerging Technologies (FET) projects to collaborate in areas such as quantum physics, supercomputing, robotics and life sciences. The aim of this 'cultural exchange' is to explore cutting-edge science from a different angle in order to stimulate societal discussions and reach out to new audiences for FET research. The six artists, who were chosen out of over 260 applications, are working closely with the FET projects MRG-Grammar, QuProCS, RySQ, DIACAT, INTERTWINE, MANGO, and subCULTron.

Joining the dots with FET

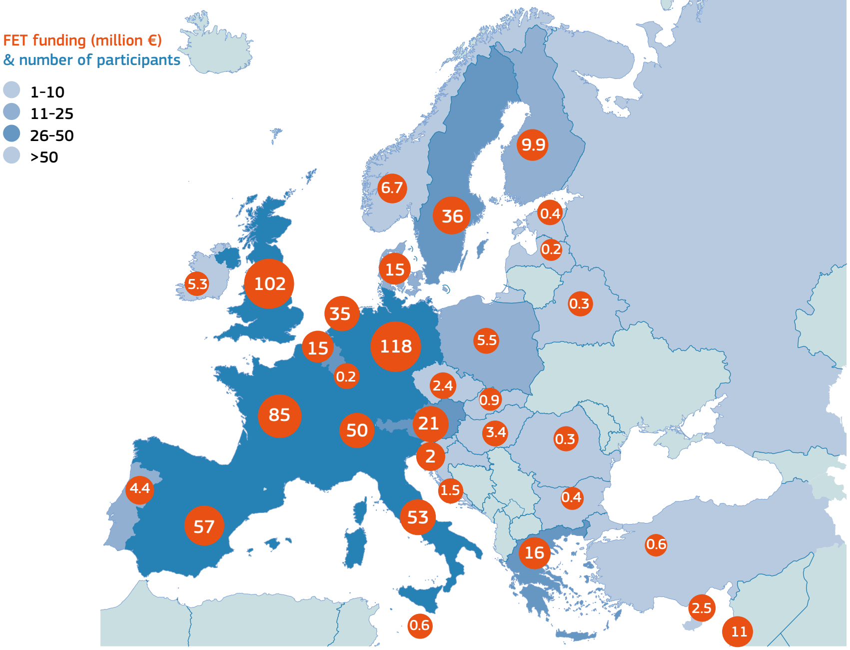


A visualisation of the FET community network in Horizon 2020: the circles indicate project beneficiaries, with the lines linking coordinator to participants.

The data covers H2020 FET Proactive and Open from 2014 to 2016, representing 144 projects, 557 participating organisations located in 36 countries and 324 cities.

FET in H2020

Participation in FET Projects*



* As December 2016 (131 projects)

The infographic shows the participation in Horizon 2020 Future & Emerging Technologies (FET) projects, indicating the round-off number of participants per country and distribution of funding as of December 2016.

Under Horizon 2020, FET actions have been allocated a provisional budget of 2 696 million Euro to initiate radically new lines of technology through unexplored collaborations between advanced multidisciplinary science and cutting-edge engineering.

Up to December 2016, a total of 659 million euros has been made available to support 131 projects, including Research and Innovation Actions, Coordination and Support Actions and Framework Partnership Agreements.

The FET participants come from 36 different countries in Europe and beyond. Germany, United Kingdom and France remain countries with the biggest number of participants. The Netherlands and Switzerland in turn have increased the amounts of funding by over 50% since June 2016. Newcomers at the end of 2016 were Latvia, Luxemburg, Malta and Romania.

KK-02-17-083-EN-N

More information

Digital Single Market website

Horizon 2020 website

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