EuroTech Universities
Excellence in Science and Technology

POSITION PAPER ON FUTURE FET FLAGSHIPS

EUROTECH UNIVERSITIES ALLIANCE

The EuroTech Universities Alliance is a strategic partnership of leading European universities of science & technology committed to excellence in research and developing solutions to the grand challenges of society. The members are **Technical University of Denmark (DTU), École Polytechnique Fédérale de Lausanne (EPFL), Eindhoven University of Technology (TU/e) and Technical University of Munich (TUM).**

As part of their mission to address the major societal challenges, the EuroTech Universities have close ties with industrial partners and operate in strong eco-systems of start-ups, SMEs and large multi-national companies. They seek to **inspire society about the opportunities offered by technology** – raising awareness among policy makers, industry and the next generation of students.

INTRODUCTION TO POSITION PAPER

In preparation of the High Level Round Table hosted by Commissioner Oettinger on 15 December 2016, this position paper represents the views of the EuroTech Universities on the future FET Flagships. It highlights the main **science and technology challenges** to be addressed, based on input received from **leading scientific experts in the relevant fields** across the four universities, as well as **endorsement by the EuroTech Universities' leadership**.

The EuroTech Universities support the selection of the following FET Flagship candidates:

- **THE FUTURE OF HEALTH CARE: DEEP DATA, SMART SENSORS, VIRTUAL PATIENTS AND THE INTERNET-OF-HUMANS**
- **RENEWABLE ENERGY – CONVERSION & STORAGE CHALLENGE**
- **ROBOTICS COMPANIONS FOR CITIZENS+++**
- **NANOARCHITECTRONICS**
- **EUROPEAN TIME MACHINE**
- **ULTIMATE EARTH PROJECT**

The detail on why these FET Flagship candidates should be supported are outlined in the subsequent pages of this position paper. In some cases, the EuroTech Universities support the FET Flagship candidate topic as it was submitted as part of the bottom-up consultation. In other cases, the EuroTech Universities propose to broaden the original candidate topics, in order to address more relevant science and technology challenges which support Europe's global scientific position and the competitiveness of its related industries.

THE FUTURE OF HEALTH CARE: DEEP DATA, SMART SENSORS, VIRTUAL PATIENTS AND THE INTERNET-OF-HUMANS

What is the S&T challenge that the candidate FET-flagship should address?

A 'revolution' is required to overcome the current challenges of healthcare systems, based on technological developments in two areas:

1. **Novel -omics analyses, imaging techniques and techniques to deepen the understanding of metabolism mechanisms** and to know much more about the patient, including concepts to integrate data, **big data/deep data analytics (virtual patient/virtual twin).** This allows for a patient-specific prognosis and therefore much more efficient management of disease.
2. Such an 'individual twin' could be continuously updated by **multi-level advanced smart sensors**, hence every European could be accompanied by such a twin throughout life (guardian angel).

Why is a Flagship necessary?

As people live longer, there is an increase in age-related, lifestyle and chronic diseases, and healthcare systems are facing **major associated challenges**. Further, most healthcare systems are still too focused on 'treatment of disease' rather than **preventative healthcare**. Technological advances create considerable potential for **improving existing and developing new healthcare solutions**.

Achieving the necessary technological advances will require a **pan-European effort**, with support of Member States. **Cross-sectoral interdisciplinary research** at the level of a FET Flagship – involving academia, industry, and the healthcare sector - is vital, in order to catch-up with the **fast developing ICT market** and to best **integrate new ICT technologies**.

Why is it good for Europe?

According to Eucomed,[1] the MedTech sector has been growing by 4% per year in the past six years. Across over 22,500 companies (of which 95% are SMEs), the sector employs more than 575,000 people and has an annual turnover of €110 billion (of which €4 billion is invested in R&D). A coordinated **pan-European effort is required to compete globally** (especially with the US) and to create a **common European market for health care systems and products**, thereby further fostering business opportunities. There is a well-established publicly supported healthcare system in Europe, but reform is required to raise its efficiency and to address the escalating costs.

What would it take to do it?

A **multi-disciplinary and cross-sectoral approach** must be followed covering the different emerging technologies and embedding them into the various framework conditions of Europe's health care systems. A **coordinated action** of academia, industry and the public healthcare sector across Member States is vital in this endeavour towards a **common vision of truly individualised health care and disease prevention**.

What could be the role of ICT in addressing the challenge?

New ICT technologies are being increasingly integrated in the health sector and discussions centre more and more on the **virtual patient** and even the 'virtual doctor'. The backbone of this ICT push is how **to collect and integrate data**. The FET Flagship proposal includes these most important ICT technologies, including **imaging technologies**, **connected sensors** (through Internet of Things), **machine learning models** and ensuring **data security**. The ICT revolution in the area of medicine is already underway, but it will require a common effort to design it in a way that is acceptable for patients, manageable for doctors and the health care system and an added value for society.

[1] http://www.medtecheurope.org/node/659

RENEWABLE ENERGY – CONVERSION & STORAGE CHALLENGE

This is an **expansion** of the original FET Flagship proposal "Direct Conversion of Solar Energy: Renewables and More". The EuroTech Universities recommend that a FET Flagship within energy should be broadened to focus on the **S&T challenge of conversion and storage of all types of renewables**.

What is the S&T challenge that a candidate FET-flagship should address?

S&T development is highly required in the **conversion and storage of renewable energies** to enable a smooth transition from fossil fuel-based to sustainable energy-based energy supply, extensive re-use of existing infrastructure, the wider application of many known technologies and the development of new ones. Current S&T efforts focus mostly on small elements of the energy system. The FET Flagship should contribute to a **S&T systems-approach to storing renewable energies** from e.g. solar, wind, geo-thermal, water, chemicals etc. This requires S&T-based innovations of new system solutions with multiple interacting sub-systems and components. The FET Flagship should address the **full value-chain** from production, conversion, transport, storage solutions, distribution and use of energy as well as security of energy infrastructure.

Why is a Flagship necessary?

According to the European Association for Storage of Energy,[2] energy storage and conversion is a key enabler of the world's decarbonisation. The main associated challenges to be addressed include cost reduction of new technologies and assessing the value for society. This requires a **pan-European effort and broader international collaboration**. The FET Flagship should address the **exponential growing global energy demand**. An overarching, visionary and coordinating FET Flagship is required to focus on conversion of all types of renewables - with energy storage and conversion technologies that ensure energy security, optimal use and production of e.g. chemicals.

Why is it good for Europe?

The FET Flagship would contribute to the **vision of a European Energy Union** and reach a scale that cannot be achieved by a single Member State. It would play an essential role in **strengthening diversity in the European energy system** by integrating multiple renewable technologies, by increasing security of energy supply and by avoiding dependency on energy from countries outside of the EU.

The EU has a wealth of **globally competitive expertise** in all necessary sub-disciplines and the FET Flagship would further strengthen the **competitive advantage for European industry**. Turning the EU into an energy efficient and low-carbon economy will also **deliver jobs and growth** and will contribute to the **EU's commitments to address climate change and renewable energy targets**.

What would it take to do it?

Delivering a joint vision of completing the European Energy Union will require collaboration between Member States, research institutions, energy producers and regulators. A FET Flagship would provide the **platform for fostering synergies and coordinated efforts** across sectors, countries and domains.

What could be the role of ICT in addressing the challenge?

ICT plays a crucial role in terms of **advanced storage technologies, intelligent distribution systems and grid reliability issues**. ICT is essential for the transition of today's energy systems into true smart grids and the energy system of tomorrow. Further, ICT will facilitate the development of a more **standardized energy system** within the EU.

[2] http://ease-storage.eu/wp-content/uploads/2016/02/2015.12.04-EASE-Energy-Storage-An-enabler-of-Decarbonisation.pdf

ROBOTICS COMPANIONS FOR CITIZENS+++

What is the S&T challenge that a candidate FET-flagship should address?

A first key challenge is to **define and design an appropriate relationship between humans and robots**, which requires a deep involvement of humanities and social sciences at all levels of design. The following is required: robot ethics, user-centred design of robot companions and helpers, safe and secure robotics, the design of sociable and empathic robots in cases where robots are put into roles of social importance etc.

A second key challenge is to **study and manage the impact of robots on society**. If robots are to be omnipresent, intelligent, connected, personalised and deeply involved at all levels of society, the value of work, care, education, human social interaction, etc. needs to be reconceptualised. It will be vital to ensure a fair economic system that will not just benefit the few, but the broadest possible number of users.

Both key challenges could be summarized under "**Responsible Robotics"** - a theme that resonates with current developments in responsible approaches to data science, as well as Artificial Intelligence.

Why is a Flagship necessary?

At the same time as Data Science and Artificial Intelligence, robotics offers one of the biggest opportunities and challenges in **social innovation and societal redesign**. Only a large scale, coherent, multidisciplinary and multi-stakeholder initiative with the scale of a EU Flagship project has the **appropriate critical mass and intellectual capability** to address such fundamental societal opportunities and challenges. Without this critical mass, technical constraints and the high costs of reliable mechanical devices will limit commercial opportunities to narrowly defined applications.

Why is it good for Europe?

Robots offer significant opportunities in **improving quality of life** for a large number of EU citizens. Their careful deployment allows the **uptake of arduous, difficult or physically impossible tasks** e.g. self-driving cars, medical robots, specialized robots to deliver packages or enhance security etc. Robots could play an important role in **enhancing physical independence** when confronted with disability, chronic disease or mobility problems. Moreover, Europe has the potential to play a leading role in human-centred, Responsible Robotics. A FET Flagship in this area will allow Europe to **attract talent and create a generation of skilled multi-disciplinary engineers** to address the challenges of redesigning and impacting our common future. Europe will need sufficient investment in robotics technologies, in order to ensure the globally competitive position for its industries, especially vis-à-vis Asia.

What would it take to do it?

A **multidisciplinary approach** is required, including the social sciences and the humanities. It will also take an **Open Science** approach, with large teams, working across many labs, in an open exchange of datasets, algorithms and experimentation. Moreover, it needs to **involve new actors**, including policy makers, economists and public opinion leaders, as well as domain specialists and entrepreneurs in domains where robots will have the highest potential impact.

What could be the role of ICT in addressing the challenge?

In the short run, **better chips, low-cost 3D sensors, versatile actuators and advances in speech understanding** will enhance current robots' services and their interactions with people. Future robot developments will likely be less constrained by developments in hardware, but based more on **developments in software**, including black box approaches of machine learning, the Internet of Things and embedded sensors and actuators. This will allow robots to become more multi-purpose devices, able to operate beyond very narrowly defined domains, and develop a more generalised form of intelligence.

NANOARCHITECTRONICS

Developments in Nanoarchitechtronics would have a significant impact on the field of cybernetics, a field emerging in the early 1960's to describe the possible **merger of machines with living organisms**. Cybernetic extensions are **items that can integrate with the body to overcome the limitations of human biology** by utilising cutting-edge concepts from biology, material science and electronics to generate bioelectronics with the ability to monitor physiological signals, stimulate tissues, restore lost tissue functions or even impose new "super human" abilities on their wearers. Examples are (a) **wearable healthcare-monitors** that can provide the user with individualized health information; (b) **prosthetics** that can replace disabled organs or body parts; and (c) **implants with the ability to transcend human biology** beyond its current limitations.

What is the S&T challenge that a candidate FET-flagship should address?

Developing new ways to interface humans, systems and the environment through **reconfigurable, adaptive and cognitive structures, sensorial surfaces and functional skins** will allow faster and multi-level interactions, providing simultaneously communication and multiple sensing functions, in an adaptive and cognitive way. The FET Flagship should address **the full value-chain for large scale implementation of the technology**. This also includes research into up-scalable nanofabrication methods and metrology.

Why is a Flagship necessary?

For the development of sensorial surfaces and skins, it is necessary to **go beyond the established trends and technologies in electronics and optics**. In particular, new materials not yet introduced/adopted in the main production lines are required, especially electromagnetic/mechanical engineered materials at micro and nanoscale. Research addressed by Nanoarchitectronics covers many disciplines and requires a **large multidisciplinary community**. A single - even very large project - would not be sufficient to develop of all the relevant aspects.

Why is it good for Europe?

The field of artificially engineered materials is **highly attractive to the international scientific community**. In Europe, multifunctional surfaces have been a key topic in H2020. The USA is heavily investing in this field and Europe will need to compete to ensure its economic potential by developing and enhancing the associated industrial applications. European universities and research institutions have excellent capabilities in all the relevant fields, but a **coordination effort and stronger partnerships** are required to be able to excel and compete with other world-wide initiatives.

What would it take to do it?

The creation and establishment of this new discipline (Nanoarchitectronics) requires the **integration and harmonization of current research initiatives**, which are currently scattered among European research centres and industry. The Nanoarchitectronics initiative would aim to federate these scattered European research initiatives and bring together all the main European actors in this field.

What could be the role of ICT in addressing the challenge?

ICT plays a very important role and the FET Flagship would have a **strong impact on ICT research itself**. Since the main objective of these sensorial skins is to guarantee a continuous flow/exchange of information between persons, systems and environment, for a multi-level interaction in an adaptive and cognitive way, it is expected that the FET Flagship will lead to a **new paradigm shift in ICT**.

EUROPEAN TIME MACHINE

This is an **expansion** of the original FET Flagship proposal “Venice Time Machine”.

What is the S&T challenge that a candidate FET-flagship should address?

The challenge is to **extract and visualize information networks from digitized documents** to build the largest ever **semantic graph of linked data about the past**; unfolding in space and time as a historical geographical information system. The aim is to constitute the first “Big data of the past” as shared patrimony for the future.

A related challenge is **processing documents through machine vision algorithms**; segmenting, indexing and transcribing content. A “Deep reading” architecture should be developed - a machine capable of mass reading and interpretation of handwritten documents.

Digitization of massive amounts of ancient archival documents is a challenge because traditional scanners are either too slow for large corpora or the materials too fragile to use traditional scanners. The goal is to develop new technologies (e.g. X-Ray tomography) for **massive digitization of the vast European heritage**. That is the starting point of the largest ever database of European archival documents.

Why is a Flagship necessary?

The above challenges offer a point of departure for a vast and integrated FET Flagship initiative pursuing **new technology in the conservation, valorization and management of cultural heritage** to the benefit of the research community and society at large. A Flagship would be necessary in order to develop the technology and to **coordinate multiple projects and networks** in different European countries and cities.

Why is it good for Europe?

Understanding the past is a key precondition for an educated democratic society. Therefore, the past should be as accessible as possible. Europe has a richer cultural heritage than any other part of the world. It is one of Europe’s most precious assets that should be **leveraged more as a driver of economic and social development**. Digital technologies now enable us to generate new ideas, new approaches to research questions and applications, and ultimately new jobs around cultural heritage.

What would it take to do it?

Achieving a true European Time Machine would require the development of **common standards and open technological patrimony**. Further, large-scale shared infrastructure for storing, analyzing and simulating the past are required. Coordinated research efforts will be necessary in all fields that are relevant to the conservation and valorisation of the heritage, including machine learning and virtual reality. This will require collaboration across disciplines and stakeholders, including academia, archives, museums and civil society. Finally, partnerships and coordination within and between Member States and European bodies and a strong link with the private sector would be necessary.

What could be the role of ICT in addressing the challenge?

ICT is required to develop **machine learning approaches to massive document analysis** and new families of historical and semantic search engines, as well as building **immersive and augmented reality interfaces** for recreating the past.

ULTIMATE EARTH PROJECT

Living sustainably on the Earth as it changes requires the development of a **full understanding of the Earth system**. As societal demands on the Earth increase, policy makers and industry must have the information necessary to make informed decisions to ensure society's safety, well-being and economic demands.

What is the S&T challenge that a candidate FET-flagship should address?

Data on the Earth and its environment is currently held in disparate poorly connected and often undiscoverable archives, including both public and private sector. The S&T challenge consists of **creating and developing an Earth Simulation and Data Storage Platform** operated as a community resource. There is a need to assess now how one can provide and then maintain a credible model for the Earth in all its states – physical, chemical and biological. The key challenges are to understand the current state of the earth and then use this to understand how it will develop in the future.

Why is a Flagship necessary?

Europe, through a FET Flagship, can take **global leadership** in the "Ultimate Earth Project". This model will need to scale to accommodate discipline-specific (climate, resources, health etc.) and national Earth, environment and socio-economic models that will develop in parallel. Only a FET Flagship project can bring all actors together in order to liberate new paradigms for the earth and create new ICT technology and associated commercial advantages and well-being for Europe and society in general.

Why is it good for Europe?

Understanding in detail the functioning of the Earth in relation to human activity is one of the greatest **challenges facing 21st century science** and Europe is a key actor. A FET Flagship would allow to gain profound insights into the mid- and long-term future of the planet and how one can use resources in a sustainable way, face climate change and its impacts, anticipate and mitigate hazards, and set-up the boundaries for the energy revolution. Europe has taken the global lead in constructing Earth and environmental infrastructure and needs to make sure that all these data can be accessed by all relevant actors for the benefit of European citizens and the economy. Having these data accessible opens up many new possibilities for developing new business models and getting into new markets in the area of green/blue economy.

What would it take to do it?

Ultimate Earth relies on the **development of a cyberinfrastructure** built to meet the current and future needs of Earth and environmental scientists. The individuals and institutions involved in "Ultimate Earth" must create the scaffolding upon which data systems can be layered, models integrated and archived. All scientific fields involved in understanding the Earth must be engaged: Solid Earth, Atmosphere, Hydrosphere, Cryosphere, Biosphere, including extra-terrestrial forces, resource and social and economic sciences. Tis comprehensive approach we allow us to address some of the fundamental questions which affect the security of humankind on this planet.

What could be the role of ICT in addressing the challenge?

ICT would be deployed to **create and develop an Earth Simulation Platform** operated as a community resource and to generate a comprehensive 3D + time model/representation of the Earth. This must encompass appropriate timescales for different processes and systems. The Model Web will support comparisons between models based on different tools and approaches and will track missing key data. Data standards and software for federated active data repositories with a focus on European data producing sites will be established.