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CHARACTERIZATION OF FET PROACTIVE

The FET PROACTIVE is a very important and prestigious module of the FET PROGRAM that combines bottom-up and top-down initiatives. It is scientifically based, breakthrough future technology orientated, with no requirement for direct industrial involvement, i.e. being at a lower half of the TRL scale. A FET PROACTIVE supports paradigm-changing inter-disciplinary collaborative research on future technologies. Such projects should stimulate the ecosystem around them to establish the best conditions for take-up beyond FET as one of their objectives. It focuses on scientifically important topics that require a stimulus and for which the relevant research community is large enough.

A FET PROACTIVE project is characterised differently from a FET FLAGSHIP. It must not necessarily carry a market potential at relatively short time perspective, and thus it is further away from the market than a flagship. Size wise it is smaller than a flagship, ranging from 3 to 10 M€ over 3-5 years and is being fully funded by the FET program. It is characterised as a High Risk, High Gain project and mostly interdisciplinary.

Due to the different scales, the broad areas of FET PROACTIVE are more fine-grained than those of the FET FLAGSHIPs.  \(^1\,^2\)

FETAG 2014 PROCEDURAL RECOMMENDATIONS

In Nov 2014, the FETAG have analysed the PROACTIVE scheme in the context of the 2016-17 WP and beyond suggesting several major changes in the scheme. As the conclusions adopted by the FETAG retain their validity we recall them in what follows:

SCOPE OF FET-PROACTIVE IN H2020

FET-Proactive should support prestigious large grants for paradigm-changing inter-disciplinary research on future technologies

A new approach to FET-Proactive is necessary to take into account the enlarged scope of FET in H2020 and to clarify the positioning of FET-Proactive vis-à-vis FET- Open and FET-Flagships.

A most important message to the scientific community is that FET is now open to all disciplines and the proposal selection procedure should reflect this openness. The public consultation showed that the interest of the research community in FET is huge, but the limited budget forces choices on the topics to be included.

- Funding a smaller number of larger cross-disciplinary projects will create the perception of a high-profile prestigious programme.

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A second key message is that FET-Proactive funds **inter-disciplinary research with a technological orientation.**

FET-Proactive should embrace the mission of promoting diversification, with respect to both principal investigators and other stakeholders, in order to **create wider eco-systems that can stimulate the uptake of the research beyond the scientific community.**

FET-Proactive should be clearly differentiated from FET-Open, to avoid proposals being submitted to both schemes

**IMPLEMENTATION OF FET-PROACTIVE IN WP2016-17**

A prestigious and publicly announced Council should be established to oversee the selection process and later the execution of the initiatives. This could be the FET Advisory Group or a subcommittee of it. To assure transparency, FET AG should not be involved. Implementation of such a Council has to be checked against the legal framework of H2020.

FET-Proactive should **support large collaborative research projects** (5 years, 10-15M€ of funding, suggested a number of integrated projects (IP) are from 3 to ~8 from a minimum of three countries) and stimulate the ecosystem around them to establish the best conditions for their take-up beyond FET.

A "cascade funding" mechanism of H2020 to get more flexibility in their implementation. This would not allow changing consortium size or composition but would facilitate short specific interactions with new participants through third party contracts up to 60 k€.

**Mid-Term Review.** At the completion of the initial term (1-2 years) EC would organise an evaluation, that among other things would assess the real collaboration between the consortium partners. At the initial term, the consortium will receive only a fraction of the budget.

The Council could carry out the assessment, in order to ensure transparency and add a label of prestige to the initiative.

**Community consultation** should be maintained for FET-Proactive. This would allow discussion and networking within emerging research communities and thematic domains.

**ERA-Net** might be considered as a possible tool for implementing FET-Proactive.

**BROAD AREAS FOR FET-PROACTIVE**

The broad areas represent the overall scope of FET to be used by decision makers and stakeholders, and in particular earmark budgets and assure that also the evaluation outcome will have a reasonable coverage of areas. They can also be used by the research communities to find the most relevant FET proactive topics. The AG three thematic fields for the FLAGSHIP were accompanied by enabling and common technologies which we have listed as a separate Proactive area. We suggest the following five broad areas:

1. **BIOMEDICAL AND BIOTECHNOLOGY FOR BETTER LIFE**
2. **ARTIFICIAL INTELLIGENCE, ROBOTICS, AND INTERACTIONS**
3. **TECHNOLOGIES FOR SOCIETAL CHANGE**
4. **NEW TECHNOLOGIES FOR ENERGY AND ENVIRONMENT**
5. **ADVANCED FUNCTIONAL MATERIALS AND NOVEL COMPONENTS**
CRITERIA FOR FET PROACTIVE TOPIC SELECTION

PRIMARY CHARACTERISTICS

- **Challenge**: the ambition of long-term vision for a new future technology.
- **Focus**: is the topic posing a clear set of high-risk technological challenges or is it rather a broad area of (scientific) investigation.
- **Relevance**: transformative impact of such technology if it were to get established (local, moderate (sectorial), high (cross-sectorial), radical (wow effect)).
- **Communities and plausibility**: do we have any indication of interest from research and innovation communities in this? Recent developments that make it plausible that anything can be achieved? No idea, vague idea, existing community, yes but new combinations/disciplines. Diversity is more FET-like. Is this community large enough?

SECONDARY CRITERIA (for guiding choices and priority)

- **Opportunity and Timeliness** – why now? Is this about catching up, or is it a new opportunity to take the lead? What makes it credible at this point? Why a push ('guided stimulus') is needed, or would it happen anyway?
- **Sizing**: is it credible to make a difference with a few projects only? If the area of investigation is too broad still, can it be narrowed down to some key issues?
- **FET role** – why is this for FET? History from FET? Could it fit, in principle, in other parts of the WP? How likely is it that the FET gatekeepers are (still) valid for a project in this area? FETAG Recommendation for particular topics
RECOMMENDATION FOR FET-PROACTIVE PARTICULAR TOPICS

FETAG Working Group on Proactive, that met in Brussels on January 12th, identified 15 particular topics within the 5 BROAD AREAS, that later were endorsed by the Full FETAG. Naturally, due to limited funds, the EC and the program Committee will choose topics (or subtopics) from this list for each call. Hopefully, in the duration of Horizon 2020 and into FP9, the full list will take part in FET PROACTIVE calls. The 15 Topics are ranked within each BROAD AREA as follows:

1. BIOMEDICAL AND BIOTECHNOLOGY FOR BETTER LIFE

1.1 Wearable and Implantable Intelligent devices

Radically new biomedical technologies that will lead to enhanced life quality for people are needed, particularly for chronic health issues or significant physical impairment. Wearable/implantable theranostic platforms that couple advances in biosensing with site-specific drug-delivery based on smart materials to control or improve a condition are included. A key goal will be to demonstrate dramatically extended functional lifetime, for example, through the incorporation of some degree of device self-awareness and self-repair capabilities. Similarly included are mobile micro/nano-devices based on biological models that can distinguish tissue types (diseased, normal) and perform highly localised actions. Minimally and non-invasive approaches based on wearable platforms such as patches and contact lenses are included, particularly from the perspective of generating molecular diagnostics on the health condition of the wearer. Likewise, soft, conformable exo-skeletal materials and structures that can sense, restore, and augment the function of limbs and joints are also included; e.g. wearables that can assist movement for rehabilitation, safety, and enhanced performance in everyday and extreme scenarios.

1.2 Regenerative medicine, artificial organs tissues and cells

Advances in cell biology, and particularly stem cell research have opened pathways towards the creation of cell assemblies, tissues, organelles, and ultimately even entire organs. Disruptive approaches that combine advances in fundamental knowledge with strategies for the practical delivery of functional biological constructs are central to this topic. These approaches will require a deep understanding of the mechanisms through which sophisticated cell behaviour is encoded, such as the triggering of complex self-assembly into 3D structures incorporating cell differentiation and multifunctional behaviour. Examples include stimulated and directed regrowth of nerve and muscle tissue, regeneration of vital organ functions (e.g. heart, liver, kidney), technology for the elderly, and 3D/4D bio-printed structures.

1.3 Futuristic Imaging and diagnostics

This topic encompasses futuristic Imaging diagnostics (including metabolic analysis) for personal medicine, that offers new possibilities for accessing critically important information about the human condition using non-invasive or minimally invasive approaches. Included are advances in imaging technologies such as PET/MRI/Acoustic scanning, extreme difference imaging enhancement (e.g. Eulerian Video Magnification), miniaturised systems for real-time multispectral imaging during surgery, and high precision and miniaturised imaging platforms that can be swallowed or injected into the blood stream. Also included are projects that integrate multi-scale information from non-invasive imaging (molecular to systemic) with in-situ biosensing and/or real-time control of microsurgical tools.
2. ARTIFICIAL INTELLIGENCE, ROBOTICS AND INTERACTIONS

2.1 Living technology

Living systems display capabilities of evolving, growing, adapting, and self-healing that are unmatched by artificial systems. Geno/phenomorpho evolution – an understanding and reconstruction of these features of biological systems would push the boundaries of evolutionary and adaptive technologies. This could combine evolutionary biology, ethology, plant and animal biology, and engineering (e.g. materials, self-configuration, programmable materials, shape-changing devices..). These technologies could be used and combined to create new approaches for manipulating DNA, switching genes on and off for medical reasons, and novel gene editing techniques in the context of simplified organisms, such as artificial cells.

Living systems, such as plants, viruses, bacteria could also be recruited for creating energy, and for performing sensing, actuation, and computation tasks. These systems could equally serve as a source of inspiration for novel computing methods or be combined in hybrid computing systems or programmable devices. Proposals that target technologies for leveraging living systems are welcome.

2.2 Mathematics of Complex Systems

New mathematical and complex systems-based technologies are needed to crunch big and heterogeneous datasets coming from social, technological, environmental, biological and health information systems, to extract knowledge from them and radically transform the way data is used. These novel approaches are expected to produce technological advances for the benefit of the society and to create data-driven science technologies that assist in decision making. This includes models for future urbanisation design, transportation flows, health systems, wind tunnels, and much more.

The topic includes subjects such as topological data analysis, new methods for reverse engineering of data, timely detection of structural and dynamical changes in complex adaptive systems, new technologies for validation, verification and quantification of uncertainty and forecasted scenarios.

Topological matter, strongly based on topology and quantum physics, is a rapidly emerging area touching the whole range of material properties: topological X are being investigated over the last decade, where X usually represents insulators or semimetals, and more recently photonics, mechanics, superconductivity, elasticity, acoustics and their combinations, among others.

2.3 Artificial Intelligence- The next Generation

Despite recent progress in Artificial Intelligence, machines do not have a cultural dimension, do not understand and express emotions or humour, do not establish social connections among themselves and with humans, do not have the same time perception as humans, lack high function linguistic skills, do not recognize faces as good as the humans do, do not have a backup plan when things go wrong, and cannot keep humans engaged for more than a few minutes. For machines, robots and personal devices to become useful and interesting companions that will enable novel forms of societal connections and improve human wellbeing in general, novel methods, algorithms, and technologies that capture those novel dimensions are required. Proposals that address socio-economic aspects of robot employment are also welcome.

2.4 Time

This initiative seeks to explore multiple notions of time and the new technological possibilities that these notions inspire. Many disciplines are concerned with time - physics of course, but also history, geology, zoology, biology, medicine (Sleep, jetlag, heart rhythms, mortality) chemistry, philosophy, psychology, epistemology, computer science, mathematics, neuroscience, literature, media and the arts. There are as many different motivations and methodologies to study and use time - often at vastly different scales and
levels of interpretation. This topic is particularly concerned with what can be learned from time-related research in terms of future technologies to, for instance, understand, measure, represent, program, manipulate, stop, create, invert, multiply, or perceive, experience and use time in its multiple manifestations.

3. TECHNOLOGIES FOR SOCIETAL CHANGE

3.1 Cities as Cyber-Physical systems

The main challenge is to understand how coordination, movement, migration, integration and interdependence of people, information, and resources through physical and social networks influence cultural, political and economic behaviour shaping the cities of the Future. The call thus seeks new technologies and methodologies that will generate radically new advances with a system-wide perspective, via integrative tools, to analyse the abundance of data coming from cities as cyber-physical systems and develop new technologies to dramatically improve city-wide management. This covers radically new approaches to the management of transport/logistics, utility infrastructure (e.g. electricity, water, ICT), and health systems at multiple spatial scales, to enable interventions from highly localised to system-wide level to be tested and optimised for maximum positive impact on society.

3.2 New Technologies for societal integration of social media

New technologies are having a major impact on society as a whole. The integration of such technologies into social settings such as the household, the school, the political system and market transactions is having a major influence on social interactions between individuals. While novel media technologies can assist in increasing interaction amongst people, they also can foster potential threats such a massive misinformation and political or economic manipulation. New technologies for information filtering and content hierarchy must be created in order to improve trust in social media and thereby enhance the educational use of social media technologies for building a better inclusive and integrated society. A transparent and trustworthy design of online institutions is a crucial ingredient to make trust and collective intelligence thrive through social media. Proposals that address these challenges are welcomed.

3.3 Embedded neural computation

Technologies for studying the influence of the social and physical environment and cultural ecosystem on the brain are required to drive a shift in focus from studying the brain under controlled, laboratory conditions, to studying the brain in a (real) environmental and social context. In addition to the development of new experimental tools and paradigms, this will require much closer cooperation between SSH and neuroscientists, in order to design experiments and to interpret the data and results, and generate new insights into how future technologies may evolve.

3.4 Prize for migration solutions

Europe is witnessing growing societal tension caused by increased mass migration, beyond normal levels of human mobility. This has been dramatically amplified by a huge influx of refugees and their non-adaptability to local societies and local standards of living, mass urbanisation, and climate change. This is not only a social issue: it is arguably the most important economic and cultural challenge of these times. Both short and long term solutions are of utmost importance to guarantee future European coherence and stability. Technological and societal solutions that will ease the challenge of social adaptability leading to enhanced social coherence is the subject of this dedicated prize.
Themes that come to mind include new models of living, pop-up urbanism, evolutionary housing, zero-waste housing. It can also include solutions and new models for social media, cultural diversity, self-fulfilment models, family contacts, and giving minorities a voice.

4. NEW TECHNOLOGIES FOR ENERGY AND ENVIRONMENT

4.1 Water availability, quality and monitoring soil, water and air

Ensuring available and usable soil, air and water are in the heart of a sustainable society. Sustainable provision of water and food, in light of climate change, is a key global challenge that requires fundamental breakthroughs in information access and use. Fresh water resources are limited and ocean water requires considerable energy to convert into usable water.

Informatics-based tools are therefore urgently needed for more effective water and land use. This will encompass new approaches to generating in situ biological and chemical information, strengthening links between in situ sensing and remote sensing from satellites, employing plants as environmental sensors (and energy production), improved and optimised tools for precision agriculture, imaginative and effective approaches to the use of cleaning water and new societal models based on sustainability. Projects addressing these challenges are invited.

4.2 Disruptive technologies for generating, storing and accessing energy

The technological challenge in energy research relates to its production, distribution and storage. The current domination of coal and hydrocarbons (gas and oil), as the main energy resources, is not sustainable in the time scale of just a few decades, as their use at current pace may lead to irreversible climate change. Moreover, the natural limitations in the supply of these fossil resources will cause a dramatic shortage of these valuable natural resources and have many more productive uses than burning for energy. At the same time, mankind has practically unlimited access to alternative power sources such as solar radiation, the wind, geothermal resources and water flow. The challenge is to create much more effective technologies and systems for electricity generation, storage and use at a local (even personal) scale, as well as thermal management with the surplus inputted to large distribution networks. This implies novel solutions for grid-level energy harvesting, distribution, storage and accounting, from highly localised and variable scale sources. Proposals that address aspects of these challenges are included in this topic.

4.3 Modelling climate Change and carbon calculations

Climate change is affecting every country in every continent. It is disrupting national economies and affecting lives, costing people, communities and countries dearly. More accurate, evidence-based predictions based on global accumulated (big) environmental data from in situ and remote sensing of key indicators like sea surface temperature and atmospheric carbon, and tracking the translocation of living organisms due to melted icebergs are included in this call, along with improved mathematical models to generate rigorously validated predictions of the current and future impacts of climate change.

5. ADVANCED FUNCTIONAL MATERIALS AND NOVEL COMPONENTS

Fundamental breakthroughs in functional materials will provide the foundations for disruptive advances in devices and services across many application domains, with the potential to positively impact on aspects of future society as diverse as personal health, energy and environment, information processing, security and
connectivity, and robotics. The combination of control of function at the molecular level, with precision 3D ordering of materials, offers particularly exciting opportunities for high impact across multiple domains.

Novel methods/technologies for creating highly innovative components based on multi-functional hybrid materials (e.g. combinations of biomaterials, semiconductors and soft polymers) and mathematical approaches like topological materials will be of prime importance for revolutionary advances in this area. Visionary projects are invited that target shape changing, adaptive, evolvable, or programmable materials, structures, components and architectures, and their incorporation into futuristic technology platforms such as self-aware biomimetic micro-/nano-fluidics, and novel materials and structures for spintronic, photonic and electronic applications. Challenges to be addressed in topological materials include compact designs and fabrication technologies and setting figures of merit and benchmarks relevant to functions.
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