

## FET Consultation - Robot Companions for Citizens ++

Proposal for a FET Flagship, by Professor Paolo Dario ([paolo.dario@sssup.it](mailto:paolo.dario@sssup.it))

on behalf of a wide community federated under the present initiative

### About you

- What is your background? Are you submitting this proposal as an individual, or do you represent a community or institution? **As an institution.**

*The Scuola Superiore Sant'Anna (SSSA, [www.sssup.it](http://www.sssup.it)) is a public University whose missions are to perform excellence research through a number of highly qualified research institutes and to provide excellent education at graduate, doctoral and post-doctoral levels, in the field of applied sciences. The BioRobotics Institute ([www.bioroboticsinstitute.it](http://www.bioroboticsinstitute.it)) performs excellent research according to the standards of the scientific communities of Robotics and Biomedical Engineering (i.e. high impact factor publications) and fosters the application and the exploitation of the research results. The BioRobotics Institute has built and consolidated a vast wealth of knowledge and expertise in the fields of Bionics, Soft Robotics, Humanoid Robotics, NeuroRobotics, Surgical Robotics, Micro-Robotics, Neural Engineering, Creative Design, Biomedical Signal Processing, Human-Robot Cooperation, Ethical, Legal and Social Issues, Robotics and Arts, and other Future and Emerging BioRobotics, as well as the know-how, the human resources (hundred graduate students, researchers, and technical and administrative assistants) and advanced facilities to build components and robots at different scales (nano-, micro-, milli- and meter). The headquarters of the BioRobotics Institute are at the "Polo Sant'Anna Valdera", a 6.000 square meter modern and functional building in Pontedera (Pisa), but the Institute has nine additional laboratories in the Tuscany area, and a large network of international collaborations in Europe and in the US, Japan, South Korea, China and United Arab Emirates, in some cases supported by joint labs. SSSA has coordinated the FP7 ICT-2011.9.5 - FET Flagship Initiative Preparatory Actions "CA-RoboCom", and has participated in the preparation of the proposal for a FET Flagship initiative "RoboCom". These experiences are unique characteristics of SSSA and were fundamental milestones for creating the scientific assets, building a community, as well as gaining knowledge of the strategic actions and risks that are required to achieve the ambitious objectives of the proposed **RoboCom++**. Some relevant past, recent and ongoing FET EU cooperative projects and coordinated by SSSA were/are: FP5 FET CYBERHAND and BIOLOCH, FP6-FET NEUROBOTICS, FP7-ICT-FET-IP OCTOPUS, FP7-ICT-IP ARAKNES, FP7-ICT-STREP ROBOSOM, FP7-ICT-FET LAMPETRA, FP7-ENV-STREP HYDRONET, FP7-ICT-FET NEBIAS, FP7-ICT-FET CA ROBOSOFT, FP7-ICT-FET CA-ROBOCOM, H2020-ICT-24 ENDOVESPA.*

### What is the challenge and the vision?

- What is the grand S&T challenge and its underlying vision and what are the main objectives your initiative would address? Why is this a grand S&T challenge and what makes it a "game-changer"?

*We believe that a new, science-based, transformative Robotics, is needed: this is the reason why we propose a RoboCom++ FET Flagship initiative. The 'New Robotics' will overcome current methods limitations and develop the cooperative service robots (or*

*Companion Robots) of the year 2030. Today's Mechatronic paradigm has serious limitations likely preventing the possibility of achieving an universal utilization of robotic systems. For example, system complexity increases with functions, leading to more than linearly increasing costs and power usage and decreasing robustness when more complex less structured task sets and environments are considered for applications. It is necessary to pursue a novel more radical scientifically principled authentically biomimetic paradigm, grounded in the scientific studies of intelligence in nature, animals and plants. This approach will allow achieving complex functionalities with limited resources and energy usage with cheap, fast and effective control and computing. Such simplification mechanisms taken from the body of ideas of 'embodied intelligence', will have to explore and exploit such ideas as "morphological computation", "simplicity", evolutionary and developmental approaches, integrated with a radically new bodyware, exploiting compliance instead of fighting it.*

- What are the main technologies, including digital technologies<sup>1</sup>, which your initiative will advance?

*This initiative will advance Robotics, AI, Cognitive sciences, Biology and will greatly impact all the areas of human living: medical and social services, manufacturing, agriculture, entertainment, humanities and the arts. It will lead to a new understanding of the brain-body nexus in the natural world thus enabling a giant leap in the technological world leading to 'machines' of unprecedented intelligence, capabilities, adaptivity and robustness. Those technologies have a potential to lead to a post-scarcity, post work economy and society thus unleashing the creative potential of human beings. The leap in technology will enable ubiquitous usage of cheap, energy efficient, sustainable robots and smart systems: co-worker robots, nurse and surgeon robots, reconfigurable architectural and urban active spaces, farming and fish farming robots, bird-like flying drones and exoskeletons. The possibilities are tremendous. Potentially any (non creative) activity now performed by humans will be implementable by soft animal-like intelligent robots. Expected outcomes of such an initiative will be self-organizing emerging orchestration controls methods, new soft materials with distributed intelligence, sensing and actuation and so on and so forth. There is a clear un-escapable need for a FET-Flagship (or similar program) on Robotics aiming at breaking through the barriers, scientific, technological, societal, still hampering the pervasive deployment of robotics solutions in the economy thus preventing the much needed unleashing of the exponential sustainable growth they promise*

#### **Why is it good for Europe?**

- Is your initiative relevant for the European industry and what is its innovation potential that would benefit Europe's economy and/or society?
- Are there existing international research initiatives linked to this proposal? How would this initiative position Europe with respect to other regions in the world?

*Europe is facing major problems and a number of challenges, ageing of the population, ageing and shortage of workforce, climate change, natural resource depletion and endangered natural eco-systems, migration border pressure from overpopulated underdeveloped neighbouring countries, dramatic increase of the cost of welfare. All those problems and challenges are threatening the future quality of life and prosperity of EU citizens. To contrast them, a dramatic increase on productivity and technological capabilities is a necessity. Robotics and AI are seen as possible solutions. Yet technical and scientific limitations make difficult to hold their promises in the long run. A FET-Flagship on new paradigm robotics will contribute to address some of these challenges, by contributing to remove the bottlenecks hampering medium-long term progress in robotics technologies and to*

---

<sup>1</sup> See in particular the EU's Digital Single Market Strategy ([http://ec.europa.eu/atwork/pdf/cwp\\_2016\\_en.pdf](http://ec.europa.eu/atwork/pdf/cwp_2016_en.pdf))?

*define a sound ambitious research program enabling a pervasive utilization of intelligent robotics and systems technologies.*

*In fact, and despite remarkable progresses in the last few years, real-world less structured environments and the complex tasks and environments of daily life activities still result extremely challenging for service robots based on the current technological and scientific paradigm. The new Science Robotics journal (<https://www.sciencemag.org/journals/robotics>) is an additional and undisputable indicator that the proposed approach is timely, needed and would fit very well the overall objectives of the FET Programme.*

*A European initiative on deeply science-based robotics would anticipate – but at the same time connect very nicely with similarly ambitious initiatives being planned in Japan, Korea and China.*

### **What would it take to do it?**

- What is the scale of the effort required to reach the objectives and how long will it take to do so?

*A 10-year ambitious and federated FET-Flagship or similar program on Robotics is needed, aiming at breaking through the barriers, scientific, technological, societal, still hampering the pervasive deployment of robotics solutions in the economy thus preventing the much needed unleashing of the exponential sustainable growth they promise. Specifically, the proposed RoboCom++ FET-F on Robotics will assess the scope of applicability of current methods and proposed alternatives, define theoretically and experimentally the more promising approaches to follow, define, test and validate, deemed necessary to implement the research strategy for “New Robotics”. It will comprise such actions as the involvement of a large interdisciplinary and multi-national community, focused research projects, fund raising (at national and international levels), social and industrial impact and efficient management. Special attention will be paid to the relationships with the national funding agencies (e.g., NRFs).*

*It will be necessary to define, for example:*

- *S&T roadmaps: the scientific contents, in terms of challenges to take, intermediate objectives, and expected results, on a timeline;*
- *Exploitation & Competitiveness strategy: the long-term exploitation plans for robot companions;*
- *ELSA framework: the ethical issues, the legal framework, the social implications (particularly those related to the issue of robots and jobs);*
- *Governing and finance structure: the organization and procedures for managing a FET-Flagship size project and the mechanisms for financial administration.*

*These long-term plans include theoretical investigations on the basic principles of robotics to allow the design of cooperative robots that can be really considered companions, as well as the design and development of core technologies and the realization of prototypes for key application scenarios. Among the theoretical investigations planned are the following:*

- *theory of morphological computation. We expect to explore a novel theoretical framework that encompasses mathematical descriptions of the principles that apply at each length scale. This framework will help to develop design principles and design tools, increase our understanding of the design space, and it will support to build the theoretical basis for the principle of orchestration. Some initial steps have been taken, but much more work is needed;*
- *understanding the design space and defining design principles: materials, mechanics, electronics, energy: We will map the range of technologies suitable for developing the envisaged robots and their behavioural properties, constraints, and energetic requirements. We will revisit the role of shape, mass, and other physical properties in the integration and design process. Evolutionary algorithms will be investigated as a tool for designing robot bodies that implement morphological computation;*

- principles of orchestration and control methods in soft, continuous, reconfigurable robots. We will synthesize principles of orchestration, a novel “control” paradigm in robots. The principles of orchestration will largely rely on unsupervised and distributed artificial intelligence methods, such as artificial evolution, swarm intelligence, and on neural computation. Our goal will not be just to adopt those methods to implement conventional control principles, but rather to capitalize on them for emergent computation.

The technologies that will be included in the long-term research are:

- multifunctional materials. New materials based on biomimetic principles, like hierarchic structures, and with self-healing properties. Another interesting challenge is to make soft responsive materials (for example based on functional, hierarchical and/or micro & nanostructured composites) capable of working as actuators and sensors at the same time and to serve as computational resource that can be exploited in the context of control, e.g. as a pure physical feedback control loop. These new soft materials need to be developed with sufficient power density to make them practical.

- energy issues. Energy consumption will be limited by the systematic exploitation of body dynamics, compliance, orchestrated control and new flexible materials. This approach may revolutionise the way in which future robots and also a wide class of machines will be designed in order to implement inherently ecologically sustainable systems;

- integrated rigid-soft structures.

Priority will be given to a part of the many application scenarios for robot companions, like industry, agriculture, healthcare, services to aging well, environmental monitoring, search & rescue where current approaches show their limits.

Due attention will be paid to dissemination, education and outreach to and involvement of EU citizens, with special attention to young people and schools, and to elderly users. A large number of stakeholders (from science and technology, society, finance, politics, industry and other relevant communities) will be actively involved aiming at community and consensus building at European and international levels. Particular attention will be paid to ethical issues (including the largely debated issues on occupation) raised by the pervasive use of Robot Companions.

- Why is Europe well positioned in terms of skills/expertise and capabilities, including industrial capabilities, to address the challenge and exploit the results? Which are the research communities to be involved?
- Are there existing national or European research initiatives linked to this proposal? What is the added value for such an effort at the European level?

Europe has a significant history of investments in Robotics. Europe is leader in manufacturing, industrial robotics and automation, and in general in the high added value mechatronic product industry. The topic has been important from FP5. In H2020 the SPARC Public-Private-Partnership on Robotics will mobilize more than 3G€ of public and private investments and there are currently more than 200 projects related to robotics at EU level, and many more funded by National and Regional Funding Organizations.

A FET-F on Robotics would be based on a strong and well organised coordination of efforts and on the construction of an interdisciplinary community beyond Robotics and AI by means of structured large-scale cooperation at the European level. By taking advantage of the experience and outcomes of CA-RoboCom (<http://robotcompanions.eu/>), its community and its scientific and technical heritage, it will go beyond and will involve a wider community of roboticists and non-roboticists, with particular attention to the natural and social science sectors (including material scientists, mathematicians, AI experts, biologists, physicists, neuroscientists, economists, sociologists, philosophers, etc.). Furthermore, specific initiatives will be needed to maintain connections with the NSFOs and with industry and the many activities already going on in Robotics for mutual stimulation and cross-fertilization.

*The proposed new FET initiative will federate existing initiatives on Robotics funded by Member States, Regions, funding agencies, industries, sharing the proposed unifying grand vision, and leading to a synergistic agenda, with a multiplier effect. Such federation has the potential to leverage other relevant initiatives even from non-EU Countries and to develop a long-lasting coordination of pan-European and international research efforts. The scouting and deep analysis of existing initiatives has already created a clear scenario of current relevant scientific approaches and achievements. A large number of endorsement letters have been already received by FLAG-ERA JTC 2016 RoboCom++ proposal on Cooperative Robotics.*

*In this decade, innovation in Robotics and AI, based on current paradigm, is unfolding and it fosters the already remarkable economic impact of those research areas (see euRobotics/SPARC: <http://sparc-robotics.eu/about/> and Boston Consulting forecasts: <https://www.bcgperspectives.com/content/articles/lean-manufacturing-innovation-robotics-revolution-next-great-leap-manufacturing/>). The proposed FET-F initiative on Robotics would actively participate and connect with the high-quality and extensive research initiatives already dedicated to Robotics within EU frameworks (i.e., FP7, H2020), with SPARC and with the many robotics-related projects at EU, National and Regional levels in order to reduce duplications to a minimum, and to rather keep and foster synergies.*

*In conclusion, a FET-F program on Robotics will allow Europe to keep and expand its leadership in Robotics and in high added value mechatronics products by focusing and exploring the potential of science-based disruptive innovations, thus protecting and improving its prosperity in the coming decades.*

***How to submit your idea to our "Digital4Science" Platform?***

*[Register to our "Digital4Science Platform](#) and  
[Submit your idea \(completed template\)](#)*

*Once your idea is submitted we will publish it on our  
[Digital4Science discussion forum](#) and it will be open for comments.*