PERIODIC REPORT

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1. Publishable summary

There is little doubt that Europe is one of the best places to live. Democracy, advanced economies, social inclusion and quality of life are ingredients of a welfare much of the rest of the world looks up to. However, the future of our welfare is far from ensured. We have big sovereign debts, weak economic growth, low competitiveness, outsourcing of productions, low job creation, little in the way of natural resources. Above all, we have unfavourable demographics: over the next 50 years, the age class 65 or over will increase its share in the EU-27 population from 17.4 % to 30.0%.

Conversely, we want more economic opportunities, especially for the young, an independent and fulfilling life, especially for older people, and greater respect of everybody's environment. We call this mismatch between our problems and our aspirations the challenge of sustainable welfare.

One of the key factors of Europe's success – together with institutions, values, human capital, political and economic freedom – is science-based technology. Indeed, Europe has historically founded its wealth and social progress on its pre-eminence in a wide range of technologies – especially machines. Sustainable welfare mirrors the limitations of today's machines.

Incremental innovation in today's robotics, though important in the short and medium term, is unlikely to address Europe's long-term concerns. This is due to a number of reasons, but especially to two fundamental, intrinsic limitations. As a matter of fact, current robots are unable to operate in complex real world conditions. Also, for a traditionally engineered system, operating in complex real world conditions would result in high demands for energy, computation and storage. At the same time, controlling it would become almost impossible. The reason is that today's robots are mechatronic modular systems, that is, sums of components. Advances in functionality imply an insurmountable increase in system complexity in terms of its degrees of freedom, joints, sensors, computation, communication, energy, human-machine interfaces, etc. Thus small functional advances will incrementally contribute to a gradual loss of controllability and robustness, and this will ultimately lead to a substantial cost in efficiency and safety.

The mission of the FET Flagship candidate "Robot Companions for Citizens" (RCC), if granted, is to address Europe's challenges by laying the scientific and technological foundations of a new future robotics. What RCC envisions is a new class of machines and embodied information technologies that will enable the construction of robots that are affordable, sustainable and dependable. This requires a fundamental rethinking of how we conceptualize and construct robots and introduce them into Society.

RCC proposes that we need to endow robots with new technologies provided by reverse engineering a number of fundamental design principles underlying natural bodies and brains in order to answer the challenge of sustainable welfare and to overcome the bottlenecks of current robotics. On the basis of this fundamental insight, RCC proposes to realize a revolutionary new generation of robots based on a cross-domain grand scientific challenge:

"To unveil the natural principles of simplexity, morphological computation and sentience and to translate the resultant scientific knowledge into design principles and fabrication technologies for Robot Companions that effectively and safely act, interact and adapt to their physical and social environment."

By investigating suitable biological examples, and "reverse engineering" their core principles, RCC will create robots that share with animals the ability to deal with complex tasks in a versatile and robust manner based on the same set of underlying principles.
This RCC Science and Technology vision is the main result of the Coordination Action CA-RoboCom, run from May 2011 to April 2012, by the joint effort of major scientific communities in Europe, in the diverse disciplines involved in this endeavour, under the coordination of Paolo Dario. CA-RoboCom has thoroughly devised and described the RCC in terms of S&T framework, governance, financial and legal structure, RTD organization, funding scheme, competitiveness strategy and risk analysis.
The RCC has been designed as a Strategic Research Agenda over a 10-year time scale and as an executable research project over a 3-year time scale, by the CA-RoboComworkpackage entitled "S&T framework of Robot Companions for Citizens" (WP1). RCC is radically novel in proposing an integrated and plausible paradigm for focused large-scale multi-disciplinary interaction and it is structured around five Pillars: MATTER (Multifunctional Nanomaterials and Energy), BODY (Morphological Computation), BRAIN (Simplexity), MIND (Sentience) and SOCIETY. Through these integrative foundational considerations, RCC will rely on a powerful and constructive dialogue between material scientists, engineers, mathematicians, roboticists, physicists, biologists, neuroscientists, psychologists, social scientists, philosophers and ethicists, in a contemporary Renaissance aiming at understanding Nature and, in doing so, generating embodied ICT solutions and tools enabling sustainable welfare. RCC exploits the synergy resulting from the convergence of past and future advances in life science—in particular neuroscience, and engineering—in particular robotics. These are both domains in which Europe has made important investments and has gained pre-eminence, but that have never met before at a scale sufficient to boost both fields and give rise to a discipline concerned with the science and engineering of a new generation of robots. By defining a clear bridge (see Figure below) between basic science, technology and Society, a unique goal-oriented synergy can be realized that warrants a flagship-scale ambition and investment by Europe.

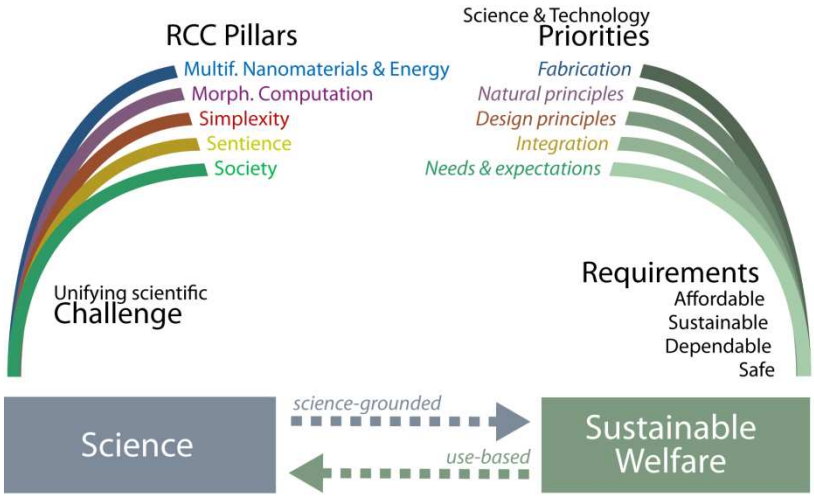

Figure 1 The RCC bridge maps the scientific vision and its implementation into concrete innovation and engineering objectives that will be driven by societal requirements.

WP1 has also led to the definition of a selective set of deployment platforms, tuned to the needs of identified user groups, that will be delivered during the ten years of the project and beyond. These deployment platforms will include:

- HealthCompanion
- ExploreCompanion
- WearableCompanion
- WorkCompanion

In the long term, the new technologies underlying these platforms will be combined into the full-scaled RCC demonstrator, the *UniversalCompanion*, which will embody, integrate, and exemplify all the major breakthroughs incorporated in the use-case specific platforms.
The following scenarios are going to show the platform functionality:

- Robot Rescuer: the robot "hero" that can search for and rescue people in debris or other natural or man-made disaster areas;
- Robot Housekeeper: a home cleaner that relieves human beings from taking care of most home chores;
- Robot Co-worker: robot tools helping workers in European factories and plants;
- Robot Pills: a class of intracorporeal robots for medical intervention, medical diagnosis or organ repair, substitution and functional regeneration, completely deployed inside the body;
- Robot Suit: a wearable robot providing support to movements and daily activities.

The workpackage entitled "CA-RoboCom: Outreach, Communication, Dissemination and Integration" (**WP2**) has included all relevant stakeholders, as well as integrated all relevant contributions to the design of the FET Flagship Candidate. The CA-RoboCom web site (www.robotcompanions.eu) includes all the information necessary to explore the content and core messages of the project as well as to understand the organisation of its consortium and collaborators and supporters, and to be part of the RCC community. Some of the most important results generated by this workpackage were the design and implementation of the Strategic Communication Plan that was established: the communication message; the identification of the targeted communities; the media & communication tools to be designed and deployed; and the communication actions to be taken within the CA-RoboCom project and their estimated calendar.
In addition, the federated planfor the education programme of RCC outlines a roadmap for the RCC Education Activities Program (EAP), functional to the scientific and technical education and trainingof future generations of RCC architects, researchers and engineers.
To answer its Grand Challenge and achieve its ambitious scientific and technological goals, RCC will mobilize a densely federated interdisciplinary effort that combines a unique amalgamation of concepts, methods and technologies. The RCC Flagship requires an effective and efficient governance structure which maximizes the impact with the resources given; procedures including a concise architecture of executive, supervisory, advisory bodies as well as smooth administration and day-to-day management. Thehe governance structure and the related complex managerial and administrative procedures have been embedded in an appropriate legal framework that makes the future RCC Flagship a capable legal entity. To this aim, the workpackage entitled "Governing, Structuring, and Financing the Future Flagship" (**WP3**) settled up an organisational structure enabling the continuous leverage of the resources required, and planned an effective and fully operational steering, governance and management structure for the future FET Flagship Initiative RCC. Sixty-four (64) prominent leaders and co-leaders from 14 Countries have been appointed so

far and accepted to serve in the RCC FET Flagship Candidate, coordinated by Paolo Dario under a strategic alliance between the IstitutoItaliano di Tecnologia, Italy and theScuolaSuperioreSant'Anna.

The CA-RoboComworkpackage entitled "Competitiveness Strategy of the Future Flagship" (**WP4**) closed the innovation loop with the industry, so to pave the way to make Robot Companions, and their components and subsystems, successful ICT products.Across the world, industrialised countries – especially in Asia – are investing in next generation robotic technologies to make factoriesand services more efficient. Europe needs to be proactive in its science and technology development in order to maintain and increase its leading position in this area. By building a new science-based robotic technology, RCC is Europe's opportunity to leapfrog the competition, as new RCC technologies will have transformative impacts in a range of settings that are currently inaccessible to robots. For instance, we expect increased efficiency in our agriculture, increased productivity in sectors such as personal and healthcare, or infrastructure construction and maintenance, that are fast becoming too costly relative to manufacturing or information services, improvements in resource harvesting and conservation of the natural world, and changes to our emergency services that will make them safer, faster, and more effective.

WP5 – entitled "CA-RoboCom Coordination and Management" – coordinated and administrated the CA-RoboCom project. The Executive Board of the CA-RoboCom Coordination Action was formed by 15 scientists from 8 European Countries. In addition to the commitment of its Consortium, CA-RoboCom has involved a wide range of external experts in (i) Working Groups *(WGs)* associated to WPs, (ii) Advisory Board *(AB)*, and (iii) European and International Cooperation Board *(EICooB)*.

CA-RoboCom identified and engaged those stakeholders that are critical to the design and description of the RCC S&T programme: 342 experts were consulted and provided written contributions or participated in one or more of the 41 Working Group meetings or of the 3 plenary meetings that were organised. Also, 22 public events and dedicated meetings were organized to meet scientific and industrial communities, policy makers, and stakeholders from Society.

RCC will continue the openness and inclusiveness experimented in CA-RoboCom, as confirmed by the wide interest and support that was gained, formalized by 136 letters of endorsement received so far from European (116) and worldwide (20) universities, research institutions and foundations, scientific societies, industries, funding agencies, national and regional governments.

The launch of the FET Flagship Initiative RCC will deliver significant benefits to science, technology, economy and Society and will bolster the coordination of European, national and further international research programmes, aiming at becoming a truly Global initiative, led by Europe. CA-RoboCom has put in place a framework that will facilitate the take-up of the different aspects of FET Flagship RCC and their integration in existing programs and the development of new approaches. Given the potential transformative and disruptive effects of Robot Companions in our Society, CA-RoboCom leveraged the broadest possible support platform, and designed a governance model for RCC. By investing in RCC, Europe enables a constructive serial disruption in a number of industries that will ensure a new sustainable welfare for European Society *in the long run*. RCC thus fits perfectly with Horizon 2020 objectives for an "Innovation Union"—excellent science, competitive industries, and a better Society.

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