The FuturICT Flagship Report

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The FuturICT Consortium

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1.1 The basics of the FuturICT concept

What is the vision?
Ubiquitous communication, sensing, and computing are blurring the boundaries between the physical and digital worlds, creating unparalleled opportunities for observing and understanding the socio-economic fabric of our world, and for empowering humanity to make informed, responsible decisions about its future. The increasingly intimate, complex and dynamic relationship between global, networked ICT systems and human society directly influences the complexity and manageability of both: of our connected, global, socio-economic system and of our modern ICT infrastructure. This also opens up the possibility to fundamentally change the way ICT will be designed, built and operated to reflect the need for socially interactive, ethically sensitive, trustworthy, self-organised and resilient systems.

From the above insight, the FuturICT project will bring together fundamental advances in Computer Science, Complexity Theory and Social Science to develop a new understanding of large-scale, socially-interactive systems with a focus on sustainability and resilience. See Figure 1.1. This will lead to:

1. Theoretical foundations for a new global systems science and a systemic risk calculus
2. A new generation of socially-aware, socially-interactive Information Communication Technologies that will build on an in-depth understanding of the co-evolution of society and ICT to realize new paradigms for self-organisation, adaptation and trustworthiness
3. A new understanding of society that will bring together, on a global level, Big Data provided by the advances in socially aware ICT technology with new modelling techniques.

FuturICT will create a new public resource – ethically-based tools and models to aggregate, access, query and understand the vast amount of data. The **Planetary Nervous System** will access and connect the data available from Open Sources, real-time devices and mobile sensors. This will be integrated with multi-scale scientific models to create a **Living Earth Simulator** which can be interrogated by policy-makers, businesspeople and citizens using the **Global Participatory Platform**. The data will be used by **Observatories and Exploratories** to develop, test and demonstrate new models of the behaviour of social, technological, environmental and economic systems.Together, these will build an eco-system that will lead to new business models, scientific paradigm shifts and more rapid and effective ways to create and disseminate new knowledge and social benefits - an **Innovation Accelerator**.

Today, far-reaching governmental policy decisions on new infrastructure, for example, are released to the public, after consultation, but with very limited means for the public to assess the quality of the inputs to the decision-making process, and to understand the implications of the outcome. Publicly available data is usually presented as text or tables, with no opportunity to question assumptions, or see simulations or geographically detailed and customisable data, that would answer questions like "How will this affect

my life?", "How will this affect my children or my parents?", "What will this mean for the future of my community or my business?".

Why do we need to move towards this vision?
Although media have been claiming that "Data is the new oil", we are still at the stage of "nodding donkeys", the devices that extracted oil from low pressure fields. Although apps have very effectively integrated small mobile devices and Big Data, we do not yet have the infrastructure equivalent to major oil wells, refineries and distribution networks. FuturICT will achieve the breakthrough scientific innovations and societal insights, new ICT systems, better policies and decision-making, and new business benefits that are needed to realise this new vision. Today, society and technology are changing so quickly that our ability to understand and influence events is being quickly overtaken. Environmental, social and financial crises can escalate quickly, threatening the safety and security of the citizens and the local or global economy. Policy-makers, individuals and businesses are faced with major decisions on how to plan the development of infrastructure, and in order to provide for a complex, uncertain future. We need to be able to respond more effectively to such crises, and to avoid creating systems that could contribute to their escalation. The resources that manage such situations should always remain open to transparent, ethical scrutiny and participation by stakeholders. FuturICT will work with policy-makers and regulators to ensure that the social and economic benefits of exploiting Big Data will benefit the individuals and organisations who may be the sources of much of the data. The data and models will be available to users through a range of modalities - as apps on mobile devices, or as complex, multi-level simulations in supercomputer centres - in other words, on phones or domes.

How will we move towards this vision?
The FuturICT flagship project will align the research of hundreds of the best scientists in Europe through a 10-year multi-disciplinary research programme that will integrate models and data from the social sciences, complexity science and ICT. Already, letters of support from over 170 institutions, research centres, funding agencies have pledged over € 70m in cash and in-kind support. There will be supercomputing support, new faculty posts, new graduate courses, new research positions and more, to support and benefit from the transformation in science and the economy that will be driven forwards by the FuturICT project.

The project's scientific direction will be set by a Strategy Board of scientists, with representation from businesspeople and other stakeholders, who will set the strategy, direction and ethos of FuturICT. An Executive Board made up of the Principal Investigators will oversee the delivery of FuturICT Focus Area Work Packages against a schedule of milestones and deliverables, and according to budget. A Science Board will integrate the scientific breakthroughs and seek out new opportunities for further research, new collaborations and novel means to exploitation. A professionally staffed Project Office will support the scientists to achieve their research goals, and liaise with the stakeholder communities who will participate in the development and deployment of the research outcomes. There will be an ERA-NET Plus that will align national funding from each participating country with the research goals and deployment of FuturICT projects. The project will be open to fresh ideas, research directions and new collaborators through issuing regular calls for proposals, and holding so-called Hilbert workshops to identify the Grand Challenges that will arise over the lifetime of the project. An annual FuturICT Week will run a series of conferences and exhibitions to showcase the research outcomes of the project to its stakeholders: scientists, businesspeople, policy-makers and members of the public.

The FuturICT Flagship project will build upon the activities carried out during the Pilot Phase Co-ordination Action. The consortium has consulted with a large number of scientists to develop ideas and concepts to achieve these goals in a scalable manner. The science will additionally build upon research activities carried out by this large network of scientists who now support the FuturICT vision. (See `futurict.eu`).

Why does it need to be a Flagship?
Although many research teams are addressing these problems, Europe needs an integrated, focussed

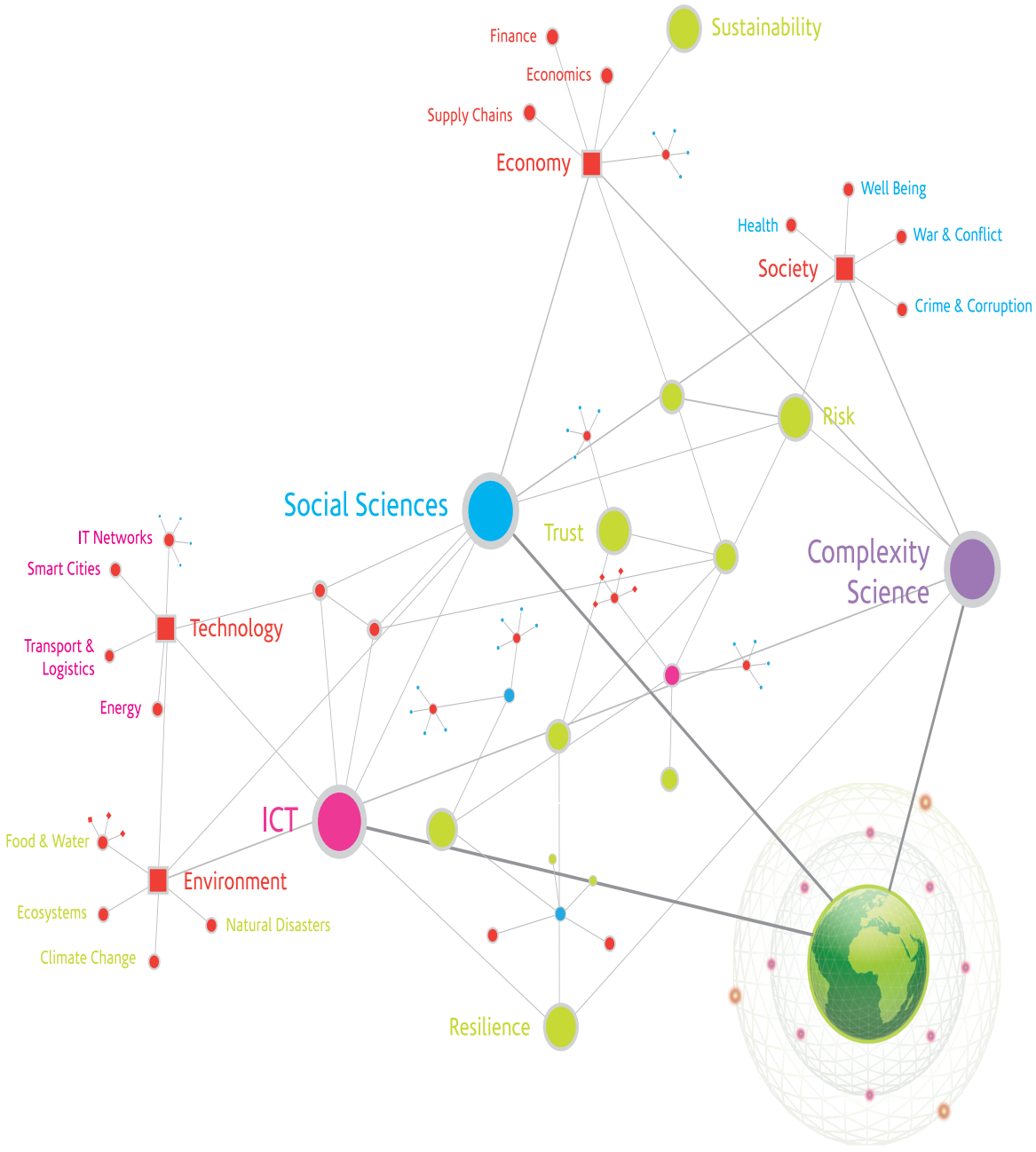

Figure 1.1: Network of sciences underpinning FuturICT

effort to achieve the required breakthroughs. A Flagship project will raise and integrate the funding and personnel resources, far beyond what could be achieved by any one nation or commercial organisation. It will muster the cooperation of many more sectors of society than those who usually engage with scientific research, such as policy-makers, businesspeople, entrepreneurs and citizens, who will participate in the development of fresh insights on the world's most pressing problems. The step-change that is needed in the policy-making infrastructure, supporting and enabling an ethical response to Big Data and scientific breakthroughs, can be best achieved by an open, public process of engagement with stakeholders, supported by a major initiative of public and private funding. A Flagship will create the impetus to encourage Universities to fund new posts and to create new courses at both graduate and undergraduate levels, so that Europe can build and sustain the trained intellectual capability that will enable and sustain our lead in this exciting new field of research, technology and business.

The importance of the FuturICT FET Flagship for Europe

The FuturICT Flagship project presents Europe with the timely combination of Big Data and the scientific and technological capability to achieve real societal and economic benefits. The FuturICT Flagship will continue the process started during the Coordination Action phase: the development of a new cross-disciplinary research community, which will establish European scientific leadership. A network of universities has been created that will contribute to FuturICT research projects, fund new posts, support super-computing and accommodate Observatories or Exploratories. This will lead to a breakthrough in innovative, interdisciplinary research, making Europe the best place for scientists wishing to pursue their career in these exciting, paradigm-shifting areas of science, delivering the vision of the FuturICT Living Earth Simulator.

FuturICT will combine the world's best scientific brains with new business models, business expertise and investors to create a new engine for growth and innovation. We will create opportunities for small businesses as well as large. SMEs will harvest value from the investment in FuturICT by creating small components based on the data analysis tools that may be mass marketed, or by adding tools and components to FuturICT's infrastructure. Larger companies, with an existing investment portfolio, will be able to collaborate with FuturICT to create new services and markets, developing tools and products that can be sold world-wide. The investment in FuturICT will lead to strategies and interventions that can be applied at policy and governmental level, leading to more efficient, less polluted cities; better plans for investment and public good; healthier communities; and better management of financial and ICT infrastructures. New ICT technologies for storing and manipulating huge datasets will create new businesses and generate sales and investment world-wide.

Through our very successful networking and collaborative efforts during the Coordination Action, FuturICT project has already had a transformative effect on the scientific communities across Europe, preparing them to fulfil the FuturICT vision of high-risk, high-impact, high-return research. The integration of research across three scientific disciplines and the national research priorities of the national funding agencies will leverage the scientific and economic benefits, beyond those that could be achieved by any one country or scientific project acting alone. The outcomes of FuturICT will potentially affect the lives of all European citizens and the competitiveness of European business for the next decades. These opportunities are too significant to be ignored and allowed to pass into the hands of unaccountable companies or to be adopted by other countries, leaving Europe unable to participate in the future.

Who will do this?

The project will be carried out by a multi-disciplinary, networked team of hundreds of scientists and researchers, building on the new FuturICT collaborations that are already in place among Europe's top universities. One thousand supporters have already expressed their interest in participating in the FuturICT project, and letters of support have been obtained from over 170 institutions and individuals, with more continuing to arrive. Concertations with existing complementary projects are being established, and new research projects are already in place, with more projects poised to begin. See Appendix 1 for a list of

letters of support, and http://www.futurict.eu/the-project/whos-involved. See Appendix 2 for a summary of the amounts of funding already pledged in cash and in kind. See Appendix 3 for a list of 175 projects under FP6 and FP7 projects that are aligned with FuturICT, indicating the extent of interest and funding that has already been committed to this research area.

Where will they do it?
The research will be carried out in universities and research institutes across Europe, coordinated by University College London and ETH Zurich. See Figure 1.2

Hubs to encourage coordination and integration of regional research activities have already been created in many European countries, e.g. Austria, Belgium, Bulgaria, Czech Republic, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Latvia, the Netherlands, Poland, Portugal, Romania, Spain, Switzerland, and the UK. FuturICT communities exist in the USA, Japan, China and Australia. Collaborations have begun with Credit Suisse, Microsoft Research, IBM Research, Telecom Italia, Yahoo! Research, Disney Research, Telefonica, Mendeley, De Nederlandsche Bank, Optimitive, Springer Publishers, SAP, Hewlett-Packard labs, and many others. At the time of writing, we have over 170 letters of support from universities, research centres and other institutions; supercomputer centres; business and industrial partners; and arts centres, government agencies, national ministries and international organisations. New letters of support are arriving every week.

1.2 The relevance of the FuturICT flagship for decision makers in the EU

What are relevant problems for politicians?
The modern world is becoming more and more complex, making it harder for policy-makers to predict the impact of their decisions and actions. High levels of interconnectivity, through transportation networks and webs of information and finance, are speeding up the spread of disease, economic disturbances, and the impacts of environmental crises, such as floods, fires and storms. National boundaries are being blurred by the scope of global companies and institutions, leading to cascading consequences, such as the financial crisis that began in 2007. Social media are enabling the rapid dissemination of ideas, for good and bad. Citizen power can be marshalled in ways that we have yet to fully comprehend, which could lead to political and economics institutions achieving profound impacts on democracy, national governance and prosperity. A leap of imagination is needed to achieve the breakthroughs that will improve our understanding of the world's economic system.

Why is it important for politicians that they are addressed?
These are profoundly complex and difficult problems, which current theories are inadequate to answer. Policy-makers need better tools to understand the causes of today's problems, and to explore the possible outcomes of their own actions and policy interventions. Without adequate resources to make effective decisions, politicians risk losing the support of their populations, leading to social disorder, economic collapse and chaos.

Before engineers build a real aeroplane, they first test it out in a simulated environment – a windtunnel. With public policies, we don't do that: we design and implement the policy, and then hope that it works. FuturICT will give use the tools to build "policy windtunnels". Through the use of the Planetary Nervous System, the Living Earth Simulator and the Exploratories, we can simulate, better understand and help to predict the intended and unintended consequences of new policies.

The FuturICT project will direct its work to helping policy-makers to address these problems, within a democratic and balanced ethical framework. The changes that technology and Big Data will bring in the next few years could profoundly affect the state of the environment, political stability and economic development. It is important that research on these changes be open and available for public comment and scrutiny, rather than being managed solely by large corporations or unaccountable institutions. FuturICT

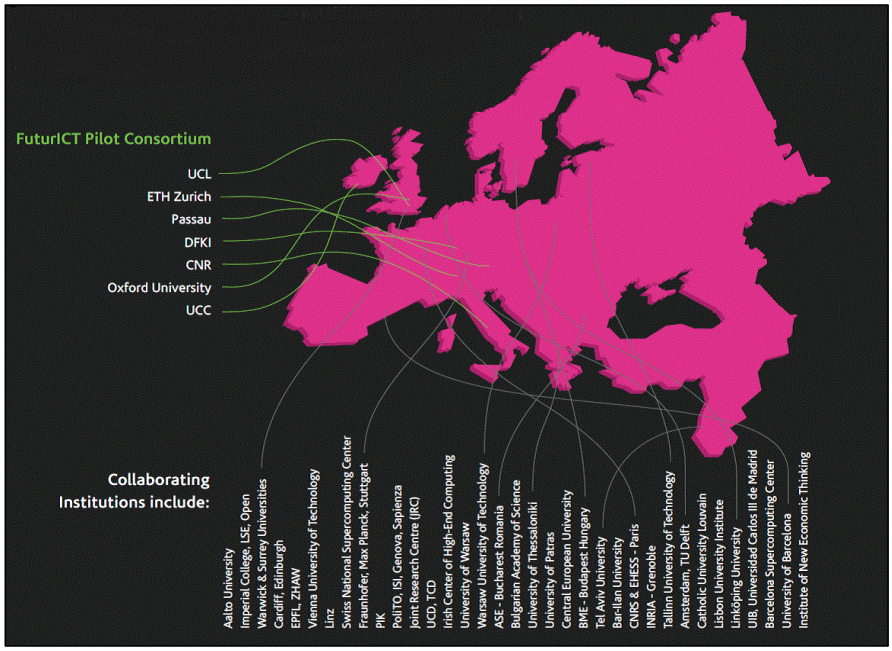

Figure 1.2: FuturICT's Network of researchers in Europe

will operate within an open environment, making the data and simulations available through a Global Participatory Platform. This will establish a new public good on which all kinds of services can be built, i.e. it will support both commercial and not-for-profit activities. To prevent misuse of the platform and to enable reliable high-quality services, it will be built on ethically-based principles of transparency, accountability, openness and trust.

How will we address them? Why is this approach worth the commitment of politicians?
Scientists have been studying the impact of complex networks of interactions between individuals and organisations, and have new models that can help us all to understand today's new, interconnected world. The FuturICT project will gather data from a number of sources, including publicly available data released by and available from governments, and data available from various mobile sensors and apps, subject to informed consent. This data will be analysed and presented in visually exciting ways by Observatories. Policy-makers, citizens and businesspeople can work with the Observatories and the Living Earth Simulator to achieve a better understanding of the world. Simulations will help people understand the range of consequences that could occur as a result of proposed policy interventions or unavoidable natural events. While we would never claim that we would be able to accurately predict the future, we expect to give a better understanding of the present, and conditions that could lead to the impact and outcomes of designed interventions, so that politicians and policy-makers may be better guided about the possible consequences of their decisions.

Support and investment in the FuturICT project could benefit citizens and society in many ways: by promoting collective awareness of the impacts of our personal and collective decisions and actions in a highly interconnected world, by mitigating global problems and systemic risks, and by creating new possibilities to participate in social, economic and political affairs. In particular, FuturICT will stimulate economic development by creating new spin-out companies and social enterprises, new business opportunities and new jobs.

The strengths of the FuturICT project are its particular and immediate societal relevance; the participation of many European and international scientific communities; the strong focus on openness and ethical issues; and the commitment to education at all levels of society. The potential benefits of FuturICT are huge in terms of new business opportunities alone; but benefits of this nature and scope cannot be provided by commercial organisations or research institutions working independently. FuturICT's combination of research, rapid deployment and ethical development is the most effective way to achieve and deliver the urgently needed benefits to society and the economy.

1.3 The FuturICT project and its relevance for EU citizens

What are the relevant problems for citizens?
Globalization and technological change have made our world a complex place. Although there have been many benefits, this change has also created some serious and challenging problems, such as financial uncertainty, political instability, rapidly spreading pandemics, and insecurity on energy, water and food supplies. These new transportation, communication and financial networks are generating huge amounts of data, much of which is available from government and public sources. By putting this data together with new models of how communication networks and social systems actually work, we can get a much better understanding of the complex behaviours that exist around us.

Why is it important for citizens that they are addressed?
The current models of how economic and political systems work are not serving us well, leading to cascades of economic and financial failures and regulatory regimes that are not adequate to prevent these problems from occurring. We need an economy that can deliver the health and social care needs of our population, and we need new and better businesses that can generate growth and create wealth. Politicians, regulators and businesspeople need to be equipped with the best possible models and tools to help them understand

and make decisions about the interventions, laws and regulations that help to sustain a democratically accountable and effective economy.

How will we address them? Why is the approach worth commitment from citizens and taxpayers?
The FuturICT project will bring together hundreds of scientists, businesspeople, citizens and policy-makers to create new models and simulations that will develop and share our understanding of today's complex world. New **Observatories** will be created to gather data and to model the forces and behaviours that drive our world. The first tranche of Observatories will include Smart Energy; Health and Epidemics; Sustainable Cities; Sustainable Financial Systems; and Social Challenges, with others to be added after the preliminary ramp-up phase. The Observatories will develop exciting visual tools to help us understand the consequences of actions and political interventions. The Observatories will be linked across Europe to create **Exploratories**, dedicated to the four areas of the Environment, the Economy, Society and Technology. Together, these will form the **Living Earth Simulator**, which will be accessible to members of the public through the **Global Participatory Platform**, making the resources and data of FuturICT available to all for scrutiny and comment.

Members of the public will be able to access the outcomes of FuturICT research and to contribute to the setting of research priorities. The FuturICT Strategy Board, which is responsible for the project's leadership and direction, will be advised by a representative panel of members of the public in order to advise on ethical considerations, suggest research priorities and problems, and to comment on the proposed research directions. Every year, there will be a FuturICT Week that will showcase the research and business benefits of the FuturICT projects, in events that will be open to the public. Each EU member country or region will have its own national or regional hub, that will have a website explaining local research, and that will host events demonstrating local research activities, outcomes and benefits. The FuturICT website will carry reports, films and demonstrations that will explain to members of the public how they can use FuturICT resources and outcomes.

FuturICT is committed to transparency, openness and ethical behaviour. The project will be under public scrutiny and subject to ethical guidance. The benefits of the project will be available to guide decisions at all levels of society, to stimulate the economy and to deliver social benefits.

1.4 The FuturICT project and its importance for scientists

The technological and social changes arising from Big Data require the development of a **new data science** that will focus on the meaning and impact of information, and will learn how new knowledge is created. The multi-layered complex networks of individuals, institutions and stakeholders that the data networks reveal will require a **new global systems science**: the science of multilevel complex systems based on real-world models and data, linking micro-level and macro-level interactions, that will belp us to design robust, reslient, multi-level systems. It will also require a **new computer architecture**, to cope with the vast amounts of data that will be held, analysed and distributed, leading to a socially-inspired ICT.

This requires a multi-disciplinary team:

- **Computer scientists and information and communication experts** to create methods, data, system architectures, tools and platforms that will allow us to imagine, create and exploit the new opportunities that Big Data will enable,
- **Social scientists** to provide characterisations of the agents within the complex socio-economic system, such as individuals, institutions, firms and nations, that may have cognitive complexity or complex responses to the surrounding world.

- **Complexity scientists** to analyse and simulate the integration of many different types of networks and agents, over a range of scales of time and scope.

What are the scientific challenges?
The fundamental scientific and technical breakthroughs that FuturICT will address will lead to:

- computational social science, suitable for Big Data, and millions of agents,
- global systems science for complex, dynamic, multi-level interaction networks,
- data science, to manage huge amounts of data, leading to the modelling of the creation of new knowledge,
- socially-inspired ICT, capable of reacting contextually to the management and presentation of information, and dynamically constructing computer network architectures inspired by social interactions.

The research approaches and assumptions of the three contributing disciplines will be integrated and extended by continuing FuturICT's programme of multidisciplinary projects, conferences, events and workshops. Current research outcomes on agent-based modelling and complex networks, visualisation and simulation will be deployed in the Observatories. The data models of the existing and proposed Observatories will be integrated to enable a smooth upgrade path through the Exploratories towards the Living Earth Simulator (LES). The ethics and security issues of storing and analysing large quantities of potentially sensitive data will affect the ICT techniques used in the Observatories, Exploratories and LES. New methods for presenting complex, dynamic data to specialists and non-specialists will be developed, creating exciting new educational methods. Simulators for policy-makers, businesspeople and members of the public will be needed that can be tailored to illustrate assumptions, explore and compare scenarios, and present the likelihoods of a range of possible outcomes.

Why is it important that science addresses these challenges now?
The Big Data deluge of the past 2-5 years is creating a **Data Push**, opening up new opportunities for economic and social benefit, but also creating risks that need to be acknowledged and addressed by a well-founded team of scientists and ethicists, supported by policy-makers and the public. If today's highly interconnected information and data networks were to remain unregulated, and poorly understood, then we could expect more and larger social, financial and technological crises. The **Policy and Ethics Pull** expresses the need for answers and solutions to the new problems the world faces. Scientists, working in teams across Europe are poised for the **Technology Push**; they already have many of the techniques and ideas to create the Observatories, Exploratories and Simulators that can be integrated to achieve the Living Earth Simulator and the Global Participatory Platform.

How will we address them? Why is this approach worth scientists' commitment?
The FuturICT roadmap indicates the opportunities for scientists to contribute their skills within flexible, multi-disciplinary teams and self-organising networks, rather than academic silos. There will be regular calls for proposals to conduct research within FuturICT's scope and vision. National hubs and FuturICT Weeks will build the extended FuturICT community of scientists, citizens and businesspeople, encouraging the formation of collaborative networks, showcasing research outputs and supporting new business models and spin-out companies. Scientists who join the FuturICT team will have access to: funding; new tenure track university posts; opportunities to leverage their output throughout the network; focussed workshops and conferences; multi-disciplinary teams; rapid publication and dissemination routes; training in modern academic skills; opportunities to exploit their research through new business models and funding; and access to a world-wide community. Calls for proposals will be issued regularly throughout the lifetime of the project to identify and support innovative research as the research develops and new research questions emerge.

1.5 The FuturICT project and its relevance for business

What are the relevant problems for business?
New 21st Century businesses require possibly long-term, collaborative research and development to understand and make use of the new resources of Big Data and mobile technologies. Although many new ideas can be developed and deployed (e.g. as apps), the difference of scale between carrying out the research and deploying the product does not lead to adequate returns on investment for many organisations. Rather than have these research resources concentrated in a few commercial organisations, we believe the benefits can be achieved and delivered more quickly, and to the benefit of more people, if the research work is carried out in close collaborative projects between the public sector and the commercial sector. This will ensure open, fair and transparent use of resources, and rapid access to the business and social benefits.

Why is it important for business world that they are addressed?
Business opportunities and business needs will be at the heart of FuturICT, through the involvement of businesspeople in the projects themselves and the strategic committees. Although the European economy is in the middle of a financial crisis, today's Data Push and Technology Push are creating unforeseeable opportunities for new business models and innovations. The advent of Big Data from social networking sites, mobile phone apps, and government sources will create novel opportunities for services, and new business and social enterprise models. The growth of new businesses that can exploit the new data resources and ICT technologies of tomorrow will be encouraged and supported by establishing bold, imaginative, far-sighted research projects and a technology transfer support team. The technical and research challenges of holding, analysing and understanding this huge new data resource would be within the capability of only a few global corporations, but by putting this capability in a publicly-funded and open research project, this creates opportunities for new ideas, new collaborations, and new businesses that are suited to European economic models and social expectations.

How will we address them? Why is this approach worth commitment from business?
The technological vision of FuturICT is based on Observatories that will gather, analyse and model data on various sectors, such as social challenges, health, financial systems etc. The Observatories will be interlinked to create four Exploratories in the Economy, the Environment, Society and Technology. Together these will form the basis of the Living Earth Simulator and the Global Participatory Platform that will enable citizens, policy-makers, businesspeople and scientists to access the most up to date understanding of the complex society.

FuturICT will create an eco-system of ideas, licensing opportunities, apps, and business spin-outs, through a network of links between researchers and businesspeople. This will be part of FuturICT's role as an **Innovation Accelerator**. The annual FuturICT Week will showcase research outcomes, and broker investment opportunities. The FuturICT website will carry information on ongoing projects, and reports of new and FuturICT exploitations. FuturICT's research agenda will remain flexible and open to new ideas and initiatives, by issuing open calls for new project proposals from consortia of collaborating organisations, such as research institutes, businesses, social enterprises, policy-makers etc.

The Strategy Board will be advised by an Innovation Advisory Board, that will seek out and recommend new ideas, directions and opportunities for realising the benefits of the FuturICT project. A professionally staffed Project Office will help with all aspects of licensing and exploitation of Intellectual Property arising from the project. The scientific leadership of the FuturICT project will be advised by a representative panel of users including businesspeople, to keep informed of the needs of business and their views on the proposed directions for research. Earnings from licensing deals, spin-out companies and royalties will be fed back to support the continuing research work of the FuturICT consortium.

The FuturICT project will support a dynamic, global network of researchers, that will bring together the best thinkers in the world from the Social Sciences, Complexity Science and ICT to address the challenges

of delivering economically significant and ethically sustainable new products and services, based on better understanding of the world's global data and ICT networks and the vast quantities of data that have only recently become available. The combination of skills will produce a world-beating team that will rapidly deliver findings, models and benefits for business and society.

Section 2

Scientific and Technical Vision and Methodology

This section will explain FuturICT's goals and the principal technical components that will be required to deliver the vision, indicating how this project will exceed the current state of the art, and will matches the Flagship vision. The technical components are developed as Focus Areas, which are further broken down to Workpackages for delivery during the ramp-up phase. We indicate the scientific breakthroughs that will be required to achieve this vision, as well as the project management that will be needed to support the vision. The integration of the scientific and management teams will be introduced, demonstrating balance across disciplines, nations and career stages.

2.1 FuturICT's 10-year vision, unifying goals and main scientific components

With the emergence of the Internet we had entered the age of instant, global availability of digital information. In a second wave of technological advances, instant access became ubiquitous as the mobile Internet spread. Finally, social networks helped channel the information flow according to social interactions, common interests, and current events. We are now at the verge of a situation where any event that happens in the real world is being instantly reflected by some piece of information in the digital domain, often automatically delivered to people to whom it is relevant. It has been this technological "perfect storm"İ that many credit for being a crucial factor, for good as well as for bad, as in events such as the Arab Spring and the recent London riots. While the extent of the impact on specific events may be disputable, there can be little doubt that we are witnessing a fundamental change in the way human society and ICT interact. ICT is not any more just a tool for information exchange and data access. Instead the boundaries between the digital and the physical domains are increasingly becoming blurred as ICT becomes an integral component of the fabric of our society. Thus, more and more ICT systems are directly coupled to complex social systems collecting and interpreting information about the real world and autonomously taking action that influences real world events. At the same time real world events are having more and more impact on the basic functionality of ICT systems.

From this insight, FuturICT will develop a platform integreating ICT, complexity science and social science that will:

- Develop a new global systems science and a systemic risk calculus for a better understanding for such socially interactive systems
- Develop methods to exploit Big Data provided by the tight coupling between the real and the digital world to gain a new understanding of collective human behaviour
- Develop new paradigms for resilient, self-organized, socially interactive ICT systems

- Develop new concepts to leverage such socially-interactive ICT technology foster stability, trust, social cohesion, and new political and economic opportunities for the citizens.
- Develop methods to better predict and control the effect of new technology on our society
- Develop new, Big Data based models of our socio-techno-economic system economics to help policy-makers and citizens manage their policy models, investments and personal futures.

The principal components of this transformation will be:

- The **Planetary Nervous System** (PNS) will bring together existing and new data sources, such as opinion tracking, mobility patterns and health data, while preserving privacy and maintaining data security.
- The **Living Earth Simulator** (LES) will combine the data with models to produce an integrated simulation of the social, economic, technical and environmental conditions of the world, enabling a better understanding of the state of our world, and its possible futures.
- A **Global Participatory Platform** will enable citizens, businesspeople, scientists and policy-makers to interact with the Planetary Nervous System, the Living Earth Simulator, the Observatories and the Exploratories, and to display the answers to their questions in new, exciting and engaging ways, using serious games and immersive technologies.
- **Observatories** will be set up in universities and research institutes across Europe as scientific and technological infrastructures fof the PNS and LES to build a better scientific understanding of specific problems, such as transmission of diseases, social challenges, sustainable financial systems and sustainable cities.
- Four super-observatories, known as **Exploratories**, will integrate the data and models from the Observatories to provide simulations and policy guidance on the **Environment**, the **Economy**, the **Society** and **Technology**.
- An **Innovation Accelerator** will speed up the development of new scientific knowledge, and achieve more rapid routes to dissemination and exploitation.

The advances in the above areas will lead to a new generation of **Socially Interactive** ICT that functions as an **Artificial Society** using principles inspired by social systems for novel self-organization, adaptation, resilience and trustworthiness.

These breakthroughs will require collaborations between scientists, policy-makers, businesspeople and citizens. Scientists from the social sciences, ICT and complexity science will work together to achieve the paradigm shift in science, achieving a new understanding of social systems, thanks to the analysis and modelling of the data deluge. Complexity scientists, who are expereinced in the analysis and simulation of the networks of interactions between agents, whether individuals, businesses, institutions or governments, will work with social sceintists who can provide new models of the cognitive and social behaviour of these agents. And new ICT will be needed to store, transmit and interact with the data and simulations. Businesspeople, policy-makers and citizens will advise FuturICT on what is needed and how it may be used, while maintaining ethical conduct and respecting privacy and societal values.

This vision is achievable, and have set out clear Success Criteria for each of the main components, described below. In Section 2.2, we present a detailed breakdown of the Workpacakges within each Focus Area, indicating for each the Main Innovation and Objectives that the WP leaders plan to deliver during the FP7 phase of the project. The rapidly evolving and highly competitive nature of planning and research in the context of global ICT makes it imposisble to plan out to long horizonz, so the governance and legal structures of FuturICT have been designed to provide flexible means to identify new projects; to form new

Figure 2.1: The FuturICT Platform

collaborations with scientists not included in the original FP7 Grant Agreement; to work with scientists in non-EU institutions; to collaborate with business so as to exploit the outcomes of FuturICT research and to indicate new potential applications; and to remain flexible and responsive to the highy dynamic nature of the field.

We explain below the vision behind each of these principal components. See Figure 2.1

The Planetary Nervous System (PNS)

One of the most profound impacts of the Internet has been in the instant, global availability of digital, archival information. Virtually any piece of relevant human knowledge is now available online. The ability to search almost instantly and to correlate vast amounts of information on a global scale has had a truly transformative impact on how knowledge is produced and used. Today, this ability is increasingly being extended from archival knowledge towards real world events as they are happening. Millions of networked sensors embedded in the physical world, e.g. in cars and phones, are sensing, filtering, interpreting and transferring data. Online games players, social media users, customers and suppliers are each creating their unique digital signature. These data can be combined with social media information, such as search queries, blogs and other digital online media to provide unexpected insights on the decisions and behaviour of agents - be they citizens, businesses, institutions or nations.

The combination of data and new devices creates a real-time shadow of the physical world in the digital domain. This "digital shadow" is clearly neither an accurate nor a coherent or complete description of specific events. Just like a real shadow, it can be exact, but it could also be incomplete or misleading.

The Planetary Nervous System will empower people to extract useful, clear and reliable informa-

tion from this fuzzy, unreliable digital shadow. The Planetary Nervous System will operate at a global level, accepting human understandable interactive queries, and automatically collecting, combining and interpreting information from heterogeneous, dynamically changing information sources. It will be tightly interwoven with large-scale, social science simulations and complexity science models, provided by the Living Earth Simulator, and complex data exploration technologies. Thus in effect, it will provide real-time information on the current global situation, e.g. social disturbances, climatic or natural events, economic and demographic data, mobility, or healthcare. A key concern in designing the Planetary Nervous System will be preserving privacy and maintaining ethical behaviour of the users. This adherence to European values, including a focus on public good, openness and transparency will distinguish the Planetary Nervous System from other similar efforts currently underway around the globe.

The Living Earth Simulator (LES)
Social scientists study the behaviour of individual agents, such as people, institutions or firms, and develop models of how the behaviour of individuals produce social structures and patterns. Complexity scientists work on models of how networks form, grow and communicate information and ideas within and between social, financial and geographical communities. The PNS data will be combined with the models developed by social and complexity scientists to build a sophisticated simulation, visualisation and participation platform, the Living Earth Simulator (LES). The data processed by this novel facility will be of a previously unimaginable scope, integrating the best scientific knowledge of all relevant computational, engineering, natural, and social sciences.

The LES will develop new methods and tools for a better understanding of techno-socio-economic systems. Flexible and intuitive simulation tools will make it easier to perform problem-driven research, since the data and models will enable the simulation of realistic scenarios. As a Flagship project, FuturICT will enable small teams of researchers across Europe to create powerful simulators that will allow the study of the assumptions, implications and differences between existing and future decision and behavioural models. To build up the simulation capacities we are calling for, the scientific community will create a toolbox of model components, which are compatible and interoperable. Successful familiar examples of such an approach are Web browser add-ons, and mobile phone apps, developed using the Open Source/open platform approach exemplified successfully by Linux and Wikipedia. By building on the FuturICT platform, this approach will overcome the challenges with the current situation, of limited functionality and mutually incompatible simulation and display tools.

The Global Participatory Platform (GPP)
The Global Participatory Platform will include interactive virtual worlds, where possible futures can be explored and enacted using techniques like those developed for multi-player online games. The purpose of these virtual copies of our world is to explore possible futures, i.e. to identify likely systemic outcomes of interactions, given certain 'rules of the game' and institutional settings. For example, one could study different kinds of financial architectures and the market dynamics resulting from them. Such participatory experiments could also inform the designs of shopping malls, airports, and future cities.

Exploratories
FuturICT will create four Exploratories, one each for Economics, Society, Technology and the Environment. See Figure 2.2. The Exploratories will act as laboratories that will analyse, model and simulate the complex techno-social systems on which modern life depends. The Exploratories will integrate the work of several ***Observatories***, each of which will focus on particular areas.

1. Exploratory of Economics As the recent economic crisis has clearly revealed, it is essential to have a better understanding of the global economic and financial systems. Due to the strong systemic interactions at all levels between economic agents, conventional approaches have not been adequate to assess economic stability. A better model of the economy will integrate the non-linear interactions between economic agents, such as financial markets, housing markets, national economies, and investment and consumption behaviour on the microeconomic level.

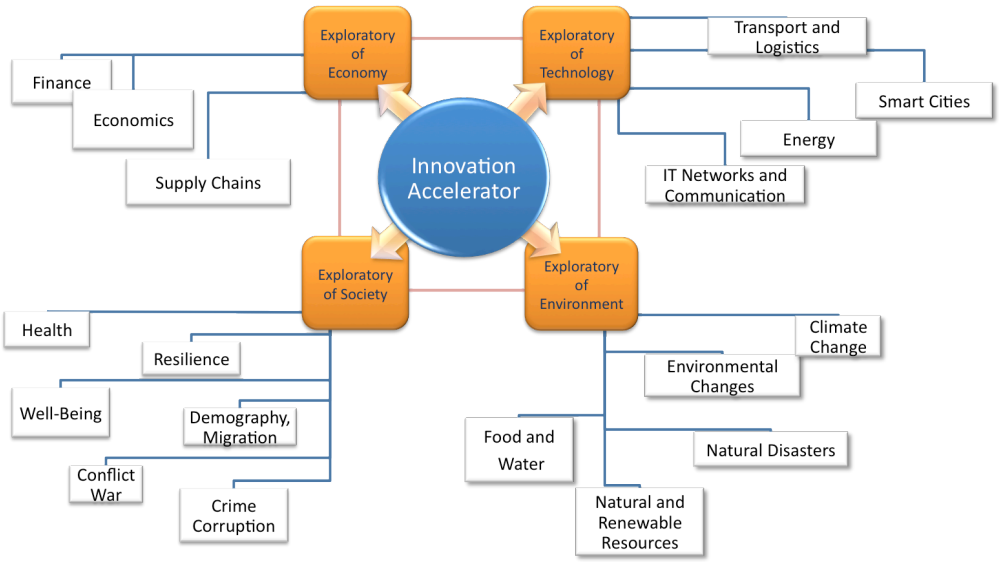

Figure 2.2: FuturICT's Exploratories on Economics, Society, Technology and the Environment.

2. Exploratory of Society The Exploratory of Society will focus on identifying factors that are likely to lead to dissatisfaction and conflict, such as social, economic or political exclusion. This will allow policy-makers and citizens to explore the likely outcomes of political actions intended to avoid social tensions that could lead to social disruption. Better understanding of the factors that affect the spread of contagious and non-contagious diseases, such as SARS, influenza, diabetes and obesity, could lead to better, more effective medical and social interventions that would improve health and reduce healthcare costs.

3. Exploratory of Technology Much of modern life depends on the safe, secure, predictable functioning of networked systems. This "Internet of Things" - sensors and actuators, embedded in physical, everyday objects - is growing at 30% each year, but will need to be understood so that it may be managed efficiently and reliably, and so that we can manage the new risks that will arise from the ad hoc integration of technical, social and economic networks. The Exploratory of Technology will lead to the smoother and environmentally friendly operation of traffic flows and energy and production supply networks. It will pay particular attention to the important properties of cascading events, which lead to system-wide impacts.

4. Exploratory of the Environment Environmental changes affect the availability of energy, health and wealth, leading to agricultural degradation, economic decline, social unrest and political instability. Data-mining activities on an aggregate level will study factors such as consumption habits, travel behaviour, recycling efforts, or energy use, which will support the uptake of environmentally-friendly behaviour.

Success Criterion: Integration of data, models and interactivity, e.g. a new platofrm for behavioural experiments and simulation.

The Innovation Accelerator (IA)

The Innovation Accelerator is an integrated ICT-based platform aimed at fostering the creation and sharing of scientific excellence by reducing all unnecessary friction of today's scientific knowledge production and dissemination. It will help people from industry, politicians and scientists to find the best experts for projects, support the communication and flexible coordination in large-scale projects, co-creation, and quality assessment. New trends will be discovered faster, allowing early investment into emerging trends and technologies.

The Innovation Accelerator requires the provision of new tools to

- support a community-specific definition of scientific quality,
- easily set up and manage large-scale scientific collaborations,
- allow efficient scientific co-creation,
- allow efficient many-to-many communication,
- promote schemes for a fair distribution of public funding based on scientific merits.

The Innovation Accelerator is expected to trigger many positive externalities, particularly for the scientific community, such as increased interactions; more scientific debates; enabling exchange between different scientific communities; improving the opportunities for scientific innovations and heterodox research approaches; and supporting all steps in the scientific production process.

Socially Interactive ICT

Despite strong coupling between ICT and society, most of today's ICT systems are "blind"İ with respect to social phenomena. Although much research has been devoted to making computers recognize the personal context of an individual, adapt their functionality to individual needs and optimize the interaction between the individual and the system, by contrast, there is very little understanding of the interaction between society as a whole and information technology. Much of the influence that information technology today has on society is unintended and random. For example, systems that deliver personalized news feeds to users base their decisions on individual preferences, but pay no attention to larger consequences such as

potential radicalization or fragmentation of public opinion. Automatic trading systems tend to optimize certain local goals, but have little awareness of the consequences of their actions for the market as a whole and on potential global crises. FuturICT will build on emerging research in areas such as Reality Mining, People-Centric Sensing, and large-scale analysis of social media to endow ICT with awareness for social context. A crucial element of our strategy will be combining research in ubiquitous sensing, machine learning and knowledge discovery with large-scale complexity science-based social models.

From social awareness, we will leverage a theory of society and ICT co-evolution, which will enable global ICT systems to autonomously adapt to social needs, to react to unforeseen events and in general to have a desirable, stabilizing effect on social processes and phenomena. The system will be able to reshuffle resources (e.g. information sources, bandwidth, distributed computing resources) to enable better monitoring and management of an emerging crisis situation to mediate interaction in and between communities and to provide emergency "slow down and ask human"İ mechanisms, preventing the system from accelerating crises and systemic failures.

In summary FutureICT will facilitate a paradigm shift, moving from a single device reacting to its immediate environment to a dynamic, globe-spanning system reacting to complex social phenomena and collective behaviors on different temporal and spatial scales. Such socially interactive systems will be directed by high level, human-formulated goals and implemented by bottom-up, self-organized processes leveraging the system's social awareness and ability to model complex social phenomena

Future ICT Systems as Artificial Social Systems

Independently of the interaction with the human society, our ICT systems are increasingly suffering from the same problems that worry societies: lack of coordination, instability, an inefficient use of resources, and conflicts of interest. The recent explosion of cyber-crime and the new notion of cyber-war leave the impression that conventionally operated ICT networks may get out of control. This is happening because ICT systems are usually not tested for the systemic interactions of their components. Yet, they are complex systems, which are made up of billions of non-linearly interacting elements (computers, smartphones, software agents etc.). More and more, these components take autonomous decisions based on an internal representation ("subjective"İ interpretation) of the surrounding world and expectations regarding future conditions. This effectively makes them artificial social systems. For example, computer-based automatic trading strategies now perform the majority of transactions in our world's financial system.

The realization that complex ICT systems can not be effectively controlled in a top down manner had led to large body of research on bio-inspired computing. Such research has led to many interesting algorithms (e.g. genetic or ants algrithms) and control paradigms for complex self-organized systems. However, we still do not know how to effectively build trusted and resilient ICT systems on the scale of artificial societies. From the background of the proposed new science of society-ICT co-evolution, FuturICT proposes to go a step further and to investigate algorithms, control methodologies and architectures directly inspired by social process and structures.

2.2 Current state of the art

Sensing

The large-scale analysis of online information related to human activities and the environment has recently emerged as a very active research field, with projects such as the MIT Reality Mining (social interactions in small communities), Open StreetMap, the Dartmouth MetroSense (metropolitan-scale, people-centric sensing), the EU SENSEI project (large-scale sensor networks and services) or the Planetary Skin Institute (global environmental change related monitoring with contributions from NASA and Cisco). In the UK, the Open Data Institute, founded in November 2011, and linking UCL, Imperial College and Southampton Universities, will be directed by Sir Tim Berners-Lee and Prof Nigel Shadbolt to demonstrate the commercial value of publicly available data. Social media data is being widely used by researchers to detect

the early onset of social shifts, e.g. trending on Twitter and Google, as a way to predict flu epidemics and social and political moods.

Responding

The notion of systems adapting their functionality to a user's activity, emotional state and their situation in the environment has led to the concept of context awareness. The early vision of context awareness has become a reality in everyday products. Modern smartphones come equipped with sensing capabilities, and a range applications exist that leverage simple context information, such as user location, motion state, and light level, to recognize the user's situation and adapt their functionality accordingly.

Stateŋofŋtheŋart approaches to context recognition mostly assume fixed, narrowly defined system configurations dedicated to often equally narrowly defined tasks. Thus, for each application, the user must deploy and place specific sensors at certain wellŋdefined locations in the environment or on his or her body. For universal context awareness, this approach is not realistic. We need systems that can exploit devices that just "'happen"'İ to be in the environment.

Interactions between users have long been considered an important part of context. However, early work focused on looking at signals from a system of a single user to establish the type of social activity in which he or she could be engaged. Typically, user location, motion patterns, and vocal behaviour would be used to determine the type of social context in which the user was engaged (for example, at a meeting, at a party, or alone). Consider the goal of developing a smartphone that knows when to ring rather than vibrate. This legendary pervasive computing problem, postulated early on, at first sounded relatively simple to solve (initial attempts using simple parameters such as environmental sound level or user location). However, despite some success, a truly satisfactory solution has so far remained elusive. This is because it requires an elaborate understanding of the social context.

One of the most profound recent ICT developments has been the transition from computer control via explicit commands to implicit, situation-driven interaction (see, e.g., the EU FET initiatives Invisible Computer and PERADA). Thus, instead of waiting for detailed, explicit commands from the user, systems increasingly analyse the environment and automatically take appropriate actions. Understanding such systems and their interaction with society is an open scientific problem, where only some initial work has been carried out (e.g. in the EU project SOCIONICAL).

Modelling

Complexity-theory-based analysis of social systems is also a burgeoning research field. However, the notion of planetary-scale, comprehensive models of society is a fundamentally different problem. While the vision of such an approach is not entirely new, previous efforts in the US, known under the name Sentient World, were terminated primarily due to lack of transparency and public control. This is a problem which does not apply to the FuturICT flagship due to its transparent, privacy-respecting and publicly-controlled approach.

Network theory allows one to understand and improve the resilience of systems. It has furthermore enabled Google's powerful page rank algorithm, and the semantic web as well as trust and recommender systems. In addition, social networking applications and models for the evolution of social groups and communities have mutually inspired each other.

Comparable large-scale projects

A few comparable large-scale projects have been launched. For example, the UN has recently launched an initiative called Global Pulse. This project aims to exploit the vast amount of data generated as a by-product of human activities, and use this information to improve the overall wellbeing of society and its resilience to crises. The initiative is developing a an international network of projects working towards these goals.

CISCO and NASA have joined forces to launch the Planetary Skin Institute. The Planetary Skin Institute uses data collected from sensors across the global to monitor global enviromnental change. Microsoft launched the Modeling the World project in May 2010, also with the aim of understanding financial systems and the impact of natural disasters given as examples.

The US Department of Defense previously launched in 2007 a project with similar aims, known as Sentient World, which was intended for use as a war-gaming simulation tool, that would include models of the geographic and physical resources of a location, with information about the psychological state of the inhabitants.

A clear industry competitor is Google. Through users' interactions with their search engine technology and other services which they offer, Google have collected substantial information on the interests and subjects of attention of the world's society today. They have demonstrated how changes in such information can be used to monitor society in a range of ways; for example, anticipating patterns in flu infection reports, or predicting changes in house prices.

The key difference and advantage of FuturICT over these existing projects are:

1. it will bring together a much larger and more diverse team than could be recruited and supported by industry, combining youth and experience, scientific and managerial excellence, and experts from ICT, complexity science and social science;

2. As a publicly-funded project, FuturICT will be conducted openly and ethically, so that its outcomes will receive scrutiny and debate from scientists who will contribute to the development and dissemination of the science, but also from professional ethicists, businesspeople and members of public who will ensure that the outcomes of the project are produced fro the common good, and will be available for exploitation and utilisation.

2.3 Matching the FuturICT proposal to the Flagship Call

The FuturICT project is by its very nature a Flagship initiative. It is **science driven**, striving to vastly increase our understanding of the behaviour of our global human society. It is **multidisciplinary**, requiring input from computer scientists, experts in the mathematics of complex systems, and researchers with solid knowledge of the substantial achievements of social science to date, and pushing new advances in each of these areas which could not be achieved by scientists from one of these disciplines alone. It has a **unifying goal**, where the strength of this unifying power has been repeatedly demonstrated during our Flagship initiatives, attracting over 1,000 supporters, over 160 submissions to a call for proposals for FuturICT research, and leading to the establishment of FuturICT hubs in over 20 European countries. It has a **long term vision**, focusing on the irreversible change in science and society driven by the vast quantities of data which our everyday activities are now generating, and identifying effective and efficient ways to begin exploiting this new resource to lay a stronger foundation for generations which follow. It has **immense scale**, in terms of the size of its scientific ambitions, the range of areas upon which the project's success would have immense beneficial impact, and the vast quantity of scientists, industry workers, policy makers and citizens which the project has already succeeded in bringing together. It plays a strong **federating role**, providing common structure for a vast collection of research efforts which were previously fragmented across discipline and nation, building a research core of unprecedented strength to support and promote Europe's scientific future.

Why Europe needs the FuturICT Flagship

Europe needs to pool resources and expertise to address such a large challenge. Already, the EU and national funding agencies are spending hundreds of millions of euros on projects within the FuturICT domain. We have identified several research activities and projects around Europe that are aligned with the goals of FuturICT, so this area of research is clearly of interest to scientists, and funding agencies are convinced of the need to support and develop scientific knowledge in this area. See Appendix 3. However, what can be achieved by these projects on their own, or with national coordination, is limited in its scope and vision, compared to what can be delivered by a Flagship.

For example, Observatories, that focus on topics such as Health or Crime or Big Cities, may produce excellent science and effective guidance for planners and policy-makers, but clearly these three topics are

interlinked. Without an overarching vision and support for collaboration at the most fundamental levels, the effectiveness of the science of these individual excellent Observatories could not achieve its ultimate ability to transform the design of Bog Cities, the improvement of Health and the deterrence of Crime. FuturICT will integrate these and other observatories, and will continue to create and interlink with other Observatories to yield effective benefits that could not be achieved otherwise.

As the population grows and ages, the climate changes, and ICT becomes more and more pervasive, we are facing systemic challenges and risks that have been impossible for us to identify, anticipate and manage. FuturICT will create a new Global Systems Science that will develop a new integrationist approach to the design, simulation and management of global risks. Although each part of a complex system might be aware of its own modes of failure, the impact of these failures on other loosely connected systems might have been unknown, so that when these links are exercised, a catastropic failure may ensue. A Flagship project that brings together expertise in complex systems, ICT, social sciences and engineering is needed to anticipate problems, estimate their consequences and help to plan effective strategies for responding to these situations. FuturICT will be able to provide access to data use cases, so that a more resilient and safe infrastructure may be put in place.

FuturICT is a truly inter-disciplinary project, invlving ICT, social science and complexity science. Were any one of these three disciplines not available, FuturICT could not achieve its goals. ICT is needed to acquire, store, and mine the data. New apps and business models will invovle ICT as sensors, platforms and delivery vehicles. Complexity science will apply and develop new techniques to analyse the data, and integrate it with and create new models of socio-technical system behaviour. Social sciences will be needed to model and understand the behaviour and decisions of the agents within the networks, be they individuals, firms, businesses or nations. Together, these three sciences will be extended by the challenge of managing and understanding Big Data. New sciences will be created, and the benefits of this increased understanding will be available to scientists, business people, policy-makers and citizens through simulations and participatory platforms, as well as an extensive programme of events, publications and other digital media.

Directed project structure to make more focused progress on urgent questions

In setting out the programme of work for the 30-month ramp-up phase, the FuturICT Coordinating Action team had to balance the feasible developments of exisiting resources, with what could be achieved within new initiatives in that timescale. It is important that the scientific goals of the project remain as the driving force, and that we provide opportunities for experienced and young scientists to participate and develop their skills and experience of working in large projects, albeit at a scale rarely seen. We belive that the plan that has been developed satisfies a number of requirements, including building on what is already in place, and creating the opportunities for completely novel contributions to science and technology. The scope and ambition of FuturICT has been planned with an eye on the 10-year horizon, but the ramp-up phase will deliver significant contributions.

Greater visibility for important research

The FuturICT Flagship will promote its new research outputs through many routes. The Innovation Accelerator will accelerate the development and dissemination of new knowledge to the scientific and business communities trhough innovative means to speed up publication. FuturICT Week will include conferences, workshops and public events that will demonstrate the innovative capabilities of the FuturICT Observatories, Living Earth Simulator, Planetary Nervous System and the Global Participatory Platform. Members of the public, policy-makers, journalists and businesspeople will be among the stakeholders who will have material oriented to their interests on the FuturICT website. FuturICT will link to other projects within the EU and across the world, e.g. in the USA, Australia and Singapore, where FuturICT communities are already established, demonstrating the quality of European science and the vision and outreach of the EU community.

2.4 FuturICT's Overall Objectives

The FuturICT Flagship has established a clear vision of the major components that will be in place 10 years from now, and a flexible governance and legal structure will enable those goals to be achieved, and to ensure that their benefits are delivered. The scientific objectives of the 10-year horizon Flagship project will be build and deliver the components outlined in the previous section, together with consolidating and integrating the scientific breakthroughs that will be required. These are stated as high level objectives below.

Objective 1: To build the Planetary Nervous System

Objective 2: To build the Living Earth Simulator

Objective 3: To build the Global Participatory Platform

Objective 4: To develop socio-inspired ICT and establish principles of socio-inspired Systems Design

Objective 5: To build an Innovation Accelerator

Objective 6: To develop a Global Systems Science

Objective 7: To develop new standards and interfaces for systems integration

Objective 8: To develop Exploratories of Society, Economy, Technology and Environment

Objective 9: To develop ethical and value-sensitive ICT

In the next section, these Objectives will be developed as the nine scientific Focus Areas during the ramp-up phase, supported by three management Focus Areas, that will deliver the ethical, transparent, professional management and support that FuturICT's success will require.

2.5 Description of methodology, strategic reserach roadmap with milestones and work-plan for ramp-up phase

The ramp-up phase of the project, under FP7, has been designed to build on existing excellent science and to draw in scientists and communities from across Europe within ICT, social and complexity sciences. During the FP7 ramp-up phase there will be nine scientific Focus Areas, addressing FuturICT's Objectives, stated in Section 2.4 above, and three management, coordination and outreach Focus Areas. These are:

- **Focus Area 1: PNS** - Towards a Planetary Nervous System
- **Focus Area 2: LES** - Towards a Living Earth Simulator
- **Focus Area 3: GPP** - Towards a Global Partipatory platform
- **Focus Area 4:** Socio-inspired ICT and Principles of System Design
- **Focus Area 5: IA** - Towards an Innovation Accelerator
- **Focus Area 6:** Theoretical foundations of a Global Systems Science
- **Focus Area 7:** Interfaces, Standards and Systems Integration
- **Focus Area 8:** Towards Exploratories of Society, Economy, Technology and Environment
- **Focus Area 9:** Towards ethical and value-sensitive ICT

- **Focus Area 10:** Project Management, Coordination and Flagship Framework
- **Focus Area 11:** Dissemination and Workshops
- **Focus area 12:** Openness, Outreach and Flexibility: New partners, visiting scholarships, open calls and research Prizes

The Workpackages associated with each Focus Area under FP7 are detailed below, with the Main Innovations and Objectives. Below this brief description is a list of the names of the people who will be the core leaders in that workpackage. Each Focus Area has a Focus Area Leader and one deputy; these are indicated by underlining their names in the lists below. The Focus Area leadership team includes three more experts, spanning the fields of ICT, social science and complexity science.

Each Focus Area is broken down into a number of workpackages (WPs). The leaders of each WP, with their team, will be responsible to the Focus Area leader for the delivery of the outputs of the WP.

The WP team members indicated below are the people who will recieve funding from the FuturICT project. The Focus Area and WP teams are likely to be considerably larger once the project begins, because of the matching funding and in-kind support that is being pledged by FuturICT supporters. These will play and equal role in guiding the project and achieving the deliverables, once funded.

In selecting the leadership teams for each Focus Area, we have tried to achieve balance by:

- including experts from each of ICT, social science and complexity science,
- combining researchers from different countries,
- including women and men in each Focus Area team.

Focus Area 1: PNS - Towards a Planetary Nervous System
Focus Area Leaders: Paul Lukowicz, Fosca Gianotti, John Shawe-Taylor, Dirk Helbing, Andrzej Nowak

WP1.1: Goal-driven configuration and self-organization; Paul Lukowicz (DFKI, Germany)
Collaborators: Sandra Hirche (TU Munich, Germany), Jeremy Pitt (Imperial, UK), Jon Oberlander (Edinburgh, UK)
Main Innovation: Ability to self-configure the data collection system based on high level human understandable goals and dynamically adapt and evolve it in an interactive way.
Objectives: Provide a "Google-like" interface which allows non-experts to execute complex queries involving, heterogenous, dynamic ensembles of information sources.

WP1.2: Data mining and knowledge discovery Fosca Giannotti (ISTI-CNR, Italy)
Collaborators: Andreas Krause (ETHZ, Switzerland); Bernt Schiele (Max Planck Institute for Informatics, Germany); with external support from Alex 'Sandy' Pentland (MIT, USA).
Main Innovation: An analytical framework of social mining, aimed at understanding human behaviour and the complexity of multi-dimensional social phenomena, by means of privacy-respecting automated discovery of patterns, rules and profiles from human activity records, produced by either opportunistic or participatory social sensing.
Objectives: A core set of primitives for the analysis of multi-dimensional social phenomena, pertaining to the various facets of social life (relationships, movements, desires, opinions, lifestyle) and ranging from individual, to collective, to global systems.

WP1.3: Sense-making; John Shawe-Taylor (UCL, UK)
Collaborators: James Crowley (INRIA, France); Kristian Kersting/Erich Rome (Fraunhofer IAIS, Germany); Luc Van Gool (ETHZ, Switzerland)
Main Innovation: Analysis and design of principles enabling known reliable sub-components to form larger systems that deliver more complex and varied functionality as demanded by the different domains and

user requirements.
Objectives: Two exemplar applications demonstrating reliable compositions with the reuse of components in different contexts, together with the analysis of their composite performance.

Focus Area 2: LES - Towards a Living Earth Simulator
Focus Area Leaders: Donald Kossmann, Andreas Flache, Min Chen, Dino Pedreschi, Maxi San Miguel
WP2.1: Scalable agent-based computing; Petros Koumoutsakos (ETHZ, Switzerland)
Collaborators: Silvano Cincotti (Genoa, Italy); Peter Sloot (Amsterdam, Netherlands); Sari Kraus (Bar-Ilan University, Israel)
Main Innovation: The development and validation of a predictive simulation tool for what will be central to the "policy wind tunnel". The models will include novel uncertainty quantification algorithms based on available data.
Objectives: Scalability of the software on massively parallel computer architectures (expecting to reach over 70% efficiency in 50K cores). Demonstration of predictive capabilities on a-priori defined benchmark problems.

WP2.2: Visualisation, from dome to phone; Min Chen (Oxford, UK)
Collaborators: Olga Sorkine (ETHZ, Switzerland); Dieter Fellner/Jörn Kohlhammer (Fraunhofer, Germany); Thomas Ertl (Stuttgart, Germany)
Main Innovations Development of knowledge-assisted visualization infrastructures, scalable visualization tools, overarching theories of visualization, and intelligent visualization agents; computer-assisted causality discovery technology.
Objectives: Provide LES with integrated visualization capabilities that are multi-scale (from dome to phone) and multi-space (data, model, policy, causation, etc.).
WP2.3: Open (World of) Modelling Platform; Dino Pedreschi (Pisa, Italy)
Collaborators: Dave Robertson (Edinburgh, UK); Andreas Flache (Groningen, Netherlands)
Main Innovation: Support for a core set of modelling primitives: dynamic model search and acquisition (controlling the inclusion of a new model within the LES), model management (controlling the lifecycle of a plurality of simulation and numerical models), model composition (expressing the overall knowledge discovery process as a data/model flow process), support of replicability, reuse, adaptation, evolution, provenance/traceability and interchange of complex analytical tasks and what-if explorations.
Objectives: Design and experiment on a core set of models the various phases listed in my statement: model acquisition, management, search and composition.

WP2.4: Model and Data Management; Donald Kossmann (ETH Zurich, Switzerland)
Collaborators: Anthony Finkelstein (UCL, UK)
Main Innovation: Develop an information architecture and framework for domain-specific languages for model and data management in the Living Earth Simulator. Methods to enable a wide spectrum of simulation and data mining tasks on a uniform IT infrastructure.
Objectives: Protoype implementation of at least one scientific exploratory in a cloud-computing infrastructure.

Focus Area 3: GPP - Towards a Global Participatory Platform
Focus Area Leaders: Simon Buckingham Shum, Sara de Freitas, Albrecht Schmidt, Markus Gross, Jeroen van den Hoven
WP3.1: User, application and business models; Simon Buckingham Shum (Open, UK)
Collaborators: Ann Blandford (UCL, UK); Matthias Jarke/Markus EisenHauer (fraunhofer FIT, Germany); Daniel Stauffacher (ICT4Peace, Geneve, Switzerland)
Main Innovation: A data commons and collective intelligence platform usable at different scales by diverse

users; open education for public engagement; participatory tools for large-scale deliberation; new business models for sustaining the ecosystem.
Objectives: Ten user communities (fewer than 10 users), five medium (fewer than 100) and one large (500-1000) representing a cross-section of stakeholders across the four exploratories.

WP3.2: Trusted Brokerage Platform and Incentives; Albrecht Schmidt (Stuttgart, Germany)

Collaborators: Karl Aberer (EPFL, Switzerland); John Domingue (Open University, UK); Chris Snijders (Eindhoven University of Technology, The Netherlands)
Main Innovation: Novel concepts and platforms for collaborative, participatory creation, manipulation and usage of information and models, based on the 'prosumer' model
Objectives: Build a scalable, evolvable prototype brokerage platform for use by non-experts

WP3.3: Integrated design of techno-social systems; Vittorio Loreto (Sapienza, Italy)

Collaborators: Dirk Helbing (ETHZ, Switzerland); Janusz Holyst (Warsaw University of Technology, Poland); Frank Schweitzer (ETHZ, Switzerland); Stefan Thurner (Vienna Medical University, Austria)
Main Innovation: Coordination of human and computational resources aimed at performing complex decision-making in the digital world and society.
Objectives: Behavioural models for human response and consensus management. A novel class of large-scale collaborative systems embodied in the digital-physical domain to be demonstrated on use cases and field studies of broad societal importance.

WP3.4: Serious Games and Arts; Sara de Freitas (Coventry, UK)

Collaborators: Markus Gross/Bob Sumner (Disney Research Labs, ETHZ, Switzerland); Josep Perello (Barcelona, Spain)
Main Innovation: A first-stage prototype world game platform allowing citizens, scientists and policy-makers to run serious games to test research hypotheses and case-based scenarios.
Objectives: Tests carried out of the world game environment according to metrics of: usage behaviour, hypotheses tested, and heuristics.

Focus Area 4: Socio-Inspired ICT and Principles of System Design
Focus Area Leaders Fausto Giunchiglia, Frank Schweitzer, Márk Jelasity, Alois Ferscha, Eve Mitleton-Kelly

WP4.1: Collective Awareness; Márk Jelasity (University of Szeged, Hungary)
Collaborators: Andrzej Nowak (U Warsaw, Poland); Janusz Holyst (TU Warsaw, Poland); Bruce Edmonds (Manchester Met, UK)
Main Innovation: Definition of an interface between groups of people and the planetary nervous system. We will identify socially important use cases and an incentive-compatible system design.
Objectives: Propose a specific social application built on the PNS that can plausibly lead to emergent cooperation and social self-organization for the common good.

WP4.2: Socially Adaptive ICT; Alois Ferscha (Johannes Kepler University, Austria)
Collaborators: Paul Lukowicz (DFKI, Germany); Roger Whitaker (Cardiff, UK); Ben Paechter (Napier, UK)
Main Innovation: A (socially inspired) foundation for next generation trustworthy, robust, resilient and sustainable ICTs, grounded on individual social capacity, collective social awareness, and society's values (respect for the individual, dignity, trust etc.).
Objectives: Provision of a "framework of principles" for socially adaptive ICTs, formalizing the process on how individuals engage in social activities and experience social relations (reality mining), and make it the design-, implementation-, and operational principles of forthcoming large scale socio-technical systems.

WP4.3: Design of Socially-Inspired Technologies; Fausto Giunchiglia (Trento, Italy)

Collaborators: Alois Ferscha (Johannes Kepler University, Linz, Austria); Jon Crowcroft (Cambridge, UK)
Main Innovation: Foundations and first experiments of a new, data driven, hybrid theory of decision

making (and computation,) where machines and humans cooperate to achieve objectives otherwise unreachable.
Objectives: A semantics-aware theory and algorithms for Big Data and large-scale knowledge representation, and for (data driven) decision making, which will allow one to cope with the inherent diversity among people and between people and machines.

Focus Area 5: IA - Towards an Innovation Accelerator
Focus Area Leaders Frank van Harmelen, Katy Börner, Stuart Anderson, Santo Fortunato, Dirk Helbing
WP5.1: Crowd wisdom and Incentive systems; Stuart Anderson (Edinburgh, UK)

Collaborators: Yi-Cheng Zhang (Fribourg, Switzerland); Dirk Helbing (ETHZ, Switzerland); Katy Börner (via Amsterdam, NL); Petra Ahrweiler (UCD, Ireland)
Main Innovation: Techniques for the predictable co-design of incentive structures and information environments supported by models that allow one to avoid perverse outcomes from incentive systems.
Objectives: Improved quality in standard tasks: data set annotation, search relevance and review, particularly in relation to trend identification.

WP5.2: Criteria and Methods for measuring science and innovation; Frank van Harmelen (Amsterdam, Netherlands)
Collaborators: Santo Fortunato (Aalto University, Finland); Carole Goble (Manchester, UK); George Kampis (DFKI, Germany); Loet Leydesdorff (Amsterdam, Netherlands)
Main Innovation: New methods and tools to use daily activities of scientists on the Web as a novel observation instrument to measure science in near real-time.
Objectives: An implemented "observation and analysis" platform to observe sciene in near real-time by tracing activities of scientists on the Web, plus a validated case study on a particular scientific field.

WP5.3: Towards a personalized education; Jeff Johnson (Open, UK)
Collaborators: Robert MacKay (Warwick, UK)
Main Innovation: The emergence of new ICT-enabled models for education, including new kinds of: social organization, methods of pedagogy, sources of teaching materials, and funding models.
Objectives: Increase the number of learners, things learned at given levels in a given time at reduced cost; personalization of educational concepts and content; assessment of understanding, pleasure & creativity levels.

Focus Area 6: Theoretical Foundations of a Global Systems Science
Focus Area Leaders László Barabási, Dirk Helbing, Nigel Gilbert, Vittoria Colizza, Vincent Blondel
WP6.1: Modelling Socially Interactive Systems; Nigel Gilbert (Surrey, UK)

Collaborators: Peter Hedström (Stockholm, Sweden), Andrzej Nowak (Warsaw University, Poland); Dirk Helbing (ETHZ, Switzerland); Paul Lukowicz (DFKI, Germany)
Main Innovation: Generic principles for the creation of models relevant for policy and usable by decision-makers; a much better understanding of the scope for the application of complexity science principles to socio-technical systems and their design
Objectives: A methodology for the design of policy-relevant models; working examples of complexity-inspired socio-technical systems 'in the wild', models of the co-evolution of ICT with society.
WP6.2: Network Science; László Barabási (Central European University, Hungary)

Collaborators: Janos Kertesz (Budapest University of Technology and Economics BME, Hungary); Felix Reed-Tsochas (Oxford, UK); Albert Diaz-Guilera (Barcelona, Spain); Reuven Cohen (Bar-Ilan University, Israel); Vincent Buskens (University of Utrecht, The Netherlands)
Main Innovation: Develop dynamical models that capture the evolution of real networks behind in techno-

socio-economic systems and measure the model parameters from experimental data
Objectives: Ability to predict the (1) scaling exponents and (2) evolution of at least two different techno-social networks; gain a theoretical understanding ot the connections between dynamics and function.

WP6.3: Complex Systems; Shlomo Havlin (Bar-Ilan University, Israel)

Collaborators: Eshel Ben-Jacob (Tel Aviv, Israel); Maxi San Miguel (Universitat de les Illes Balears, Spain); Sorin Solomon (University of Jerusalem, Israel); Henri Berestycki (CAMS, France)
Main Innovation: Characterize, describe and analyze the structure, function and inter-dependencies of multi level complex systems in different disciplines, such as social systems, economics, infrastructure and climate.
Objectives: Develop a realistic mathematical framework to analyze, quantify and better understand the vulnerabilities due to interactions within and between real-world complex systems, pushing complexity science towards practical applicability.

WP6.4: Data science; Vincent Blondel (Louvain, Belgium)

Collaborators: Anxo Sanchez (Carlos III de Madrid, Spain); Frank Schweitzer (ETHZ, Switzerland); Alain Barrat (Marseille, France); Patrick Wolfe (UCL, UK); Irad Ben Gal (Tel Aviv University, Israel)
Main Innovation: Automatic extraction of meaningful data from real-world systems with large complexity; learn how to transform data into information and knowledge; understand meaning and impact of information.
Objectives: Achieve automatic knowledge extraction from a social systems or networks at country scale.

Focus Area 7: Interfaces, Standards and Systems Integration

Focus Area Leaders Thomas Michael Bohnert, Ann Blandford, Phillipp Slussalek, Donald Kossmann, Alex Vespignani

WP7.1: Gaining Leadership in the Development of New Standards; Thomas Bohnert
Collaborators: Philipp Slusallek (DFKI, Germany); Gregory Provan (UCC, Ireland); Karl Aberer (EPFL, Switzerland)
Main Innovation: Creation of a massively scalable platform for BigData analytics and storage; a global, distributed platform that consolidates data, models, algorithms, and services, and provides trusted access to all stakeholders.
Objectives: A global resource federation, orchestration, and composition framework; reputation- and trust-based policy control framework for resource composition and orchestration.

Focus Area 8: Towards Exploratories of Society, Economy, Technology and Environment

Focus Area Leaders Alex Vespignani, Didier Sornette, Mike Batty, Rosaria Conte, Albrecht Schmidt

WP8.1: Sustainable and resilient financial systems; Didier Sornette (ETHZ, Switzerland)
Collaborators: Philip Treleaven (UCL, UK); Cars Hommes (Amsterdam, Netherlands); Silvano Cincotti (Genova, Italy); Guido Caldarelli (CNR, Italy); Thomas Lux (Kiel, Germany); Alan Kirman (Aix, France); Johan Pouwelse (TU Delft, Netherlands)
Main Innovation: Develop a non-equilibrium theory of economic exchange with and without markets and reference currencies.
Objectives: Find indicators that may serve as advance warnings of financial instabilities and bubbles

WP8.2: Health and Epidemics; Alex Vespignani (ISI Torino, Italy)

Collaborators: Vittoria Colizza (INSERM, France); Mário J. Gaspar da Silva (Lisbon, Portugal); Lewi Stone (Tel Aviv, Israel); Shlomo Havlin (Bar Ilan, Israel); Yamir Moreno (Zaragoza, Spain); Romualdo Pastor-Satorras (Barcelona, Spain)
Main Innovation: Provide rationales and quantitative analysis to support the decision and policy making processes in the arena of global health phenomena.
Objectives: Develop multi-level mathematical models maintaining an interface with both microscopic and macroscopic databases; create a flexible, ad-hoc large-scale computational infrastructure for crisis management.

WP8.3: Social challenges, crime and conflict; Rosaria Conte (ISTC-CNR, Italy)

Collaborators: Jean-Pierre Nadal (CNRS and EHESS, France); Shane Johnson (UCL, UK); Lars-Erik Cederman (ETHZ, Switzerland)
Main Innovation: A case study and tested procedure to raise the interest of the stakeholders in a cross-disciplinary endeavour based on PNS data with LES simulations.
Objectives: Accurate description and analysis of two main case studies (one for conflict, one for crime or criminality). Production of a best practices guidelines book for deployment of exploratories.

WP8.4: Systemic risk and resilience: Jamie MacIntosh (UCL, UK)

Collaborators: Didier Sornette (ETHZ, Switzerland); Stefan Pickl (Bundeswehr Uni, Munich, Germany); with external support from Delilah Al-Khudjairy (JRC, European Commission).
Main Innovation: Advance distributed decision support from inappropriate use of conventional risk tools to methods fit for the risks and uncertainties of co-evolving networks.
Objectives: Reliable indicators and warnings of cascading events; uptake by users of improved capabilities for distributed decisive actions; development of design principles for more resilient systems.

WP8.5: Sustainable Cities; Mike Batty (UCL, UK)

Collaborators: Kay Axhausen (ETHZ, Switzerland); Alexei Pozdnoukhov (NUI Maynooth, Ireland); Virginia Dignum (TU Delft, Netherlands)
Main Innovation: Improved quality in standard tasks; data set annotation, search relevance and review, particularly in relation to trend identification.
Objectives: To demonstrate improved systems for integrating urban data from real-time sensing and social media; provide effective and workable demonstrators for citizen participation in urban design.

WP8.6: Smart energy systems; Marco Ajmone-Marsan (PoliTo, Italy)

Collaborators: Anna Carbone (PoliTo, Italy); Tadj Oreszczyn (UCL, UK); Antonio Ferndanez Anta (IMDEA, Spain); with external support from Marcelo Masera (JRC, European Commission)
Main Innovation: Development of new algorithms and incentive structures to effectively match supply and demand. Integration of large quantities of energy generators from renewable sources within the evolving energy grid.
Objectives: Reduction of peak demand with proposed algorithms/incentives; increased percentage of energy from renewable sources integrated into national grids.

WP8.7: Environment and Sustainability; Guillaume Deffuant (Cemagref, France)

Collaborators: Jürgen Kurths (Potsdam Institute of Climate Impact Research, Germany); Valerio Lucarini (University of Hamburg, Germany)
Main Innovation: Developing a self-organizing ICT system interconnecting models and data sources about socio-economic and earth system evolutions, at different scales (from local to global); understand how environmental chane impacts society and economy (e.g. by migration and wars); learn how to promote environmentally-friendly behaviour.
Objectives: Developing a first version of the system and testing it with a core set of research teams on a set of specific issues (e.g. demographic evolution, food and water consumption, water and land availability).

Focus Area 9: Towards Ethical and Value-Sensitive ICT

Focus Area Leaders Jeroen van den Hoven, Eve Mitleton-Kelly, Stefan Bechtold, Dino Pedreschi, Alois Ferscha
Collaborators: Jeroen van den Hoven (TU Delft, Netherlands); Stefan Bechtold (ETHZ, Switzerland); Josep Domingo-Ferrer (Univ. Barcelona, Spain); Eve Mitleton-Kelly (LSE, UK); Endre Bangerter (BFH, Switzerland); Markus Christen (UNI ZH, Switzerland)
Main Innovation: Value sensitive design of a broad range of FuturICT applications, models, simulations and serious gaming. Elicitation of moral values concerning trust, identity, privacy, justice, accountability and democracy with a large number of users and stakeholders via Global Participatory Platform and throughout the FuturICT consortium. Utilization of values and ethical concerns in the formulation of

moral requirements for design and development of ICT systems, platforms and applications.
Objectives: Formulation of (1) a robust notion of value sensitive design and methodology and (2) set of principles of fair data mining for the social sciences.

Focus Area 10: Project Management, Coordination, and Flagship Framework
Focus Area Leaders Steven Bishop, Agatha Keller, Janet Smart, Thomas Bohnert, JB McCarthy
WP10.1: Management, led by Executive Board; Steven Bishop (UCL, UK)
Collaborators: Martin Scott (UCL, UK); Dirk Helbing (ETHZ, Switzerland)
Main Innovation:
Objectives: Deliver Project Office functions in UCL and ETHZ to manage the Executive Board's responsibility for delivering the FuturICT project; support the operation of the Strategy Board and principal boards and committees; coordinate interaction between FuturICT's scientific and stakeholder communities.
WP10.2: Flagship legal framework and IPR; Janet Smart (Oxford, UK)
Collaborators: Reto Largo (Interface to Climate KIC, ETHZ, Switzerland)
Objectives: Develop, review and put in place legal frameworks to enable exploitation of FuturICT outputs; design legal structures to enable smooth transition from FP7 to Horizon 2020.
WP10.3: Scientific Coordination; Steven Bishop (UCL, UK)
Collaborators: To be recruited
Objectives: Scientific Management of FuturICT deliverables; Manage events amd public relations for FuturICT; provide half-full-time management support for each scientific Focus Area leader.

Focus Area 11: Dissemination and workshops
Focus Area Leaders JB McCarthy, Rosaria Conte, Jeff Johnson, Dirk Helbing, Cars Hommes
WP11.1: Dissemination and interfaces JB McCarthy (UCC, Ireland)
Objectives: Organize events; maintain content and appearance of FuturICT website; exploit social media tools to present FuturICT output.
WP11.2: Workshops
Objectives: organize events; maintain content and appearance of FuturICT website; explot social media tools to present FuturICT output. Provide travel and subsistence support to enable integration workshops between and within Focus Areas (approved by Strategy Board); provide similar funding for national meetings and Staircase to Excellence.

Focus Area 12: New partners, visiting scholarships, open calls, research prizes
Budget allocation: to be distributed by the Science and Strategy Boards
Selection Committee: To include: Márk Jelasity (HU); Eshel Ben-Jacob (IL); Santo Fortunati (FL); Alex Arenas (ES) (ES); Jean-Pierre Nadal (FR); Panos Argyrakis (GR); Vincent Blondel (B); Stefan Thurner (A); Peter Hedström (S); Andrzej Nowak (PL), Jose Fernando Mendes (PT), plus high-level experts from other represented countries.

2.6 Scientific and technological breakthroughs to achieve FuturICT's vision

The realisation of the above vision will require fundamental breakthroughs in a broad range of ICT domains, as well as in complexity science and in the social sciences. Crucially, it will be at the interface between these three areas that many of these scientific breakthroughs will occur. However, these challenges are within our grasp, and some are just around the corner.

This section will explain the scientific breakthroughs that will be required to achieve the objectives set out at the beginning of this chapter.

Challenges in building the Planetary Nervous System
This PNS will mine massive quantities of time-resolved data to relate observed social behaviours to demographics, social networks and environments. The Planetary Nervous System builds on previous work,

such as MIT's Reality Mining initiative, extending them towards an interactive, self-configurable global platform that can be used for arbitrary high-level queries by people with no knowledge of ICT technology. Novel types of experiments involving sensors, virtual worlds and new large-scale participatory settings will require new types of methodological approaches to develop new, better grounded social theories. Thus, the key challenges are

- Integrating information from heterogenous information sources that have different spatial and temporal granularity and range, and different semantic relationships to the questions being asked. Thus for example, we would like to understand public sentiment with respect to a certain political development, from a combination of tweets, newsblogs, social media activities, tweets, newsblogs and other social media, YouTube videos, search queries, mobility data from smart phones and large scale public transport systems.
- Learning from experience of past queries and the information required to answer them satisfactorily.
- Going from a high-level, human understandable query towards automatic configuration of millions of sensors, online information sources, and associated interpretation algorithms. This will require major advances in a wide range of computer science domains, including semantic technology, machine learning, control theory and distributed computing.
- Incremental, dynamic construction of a simplified internal model of the state of human society.
- Privacy respecting, distributed reasoning and enrichment of information that allows the extraction of high-level knowledge, while losing as much as possible of the sensitive information relating to a specific individual.
- Parsimony in storing data, deciding what to keep and what to discard.
- Tight interaction with social science theories and complexity science.
- New methodologies for researching socially-inspired ICT systems.

The PNS will exceed previous work because of (a) the unprecedented scale and complexity of data collection (millions to hundreds of millions of dynamically changing, heterogeneous information sources), (b) the size of the semantic gap that the data analysis will bridge (from basic sensor data and text mining to high level processes like changes in consumer behaviour), (c) the development of a privacy-respecting data mining approach and (d) the need for autonomous configuration (and possibly dynamic re-configuration) of the required information sources and respective algorithms from abstract, high-level goals in real-time.

Challenges in building the Living Earth Simulator

The Living Earth Simulator will use a range of methods to enable the exploration of future scenarios at different degrees of detail, and from a variety of perspectives. The challenges in creating the LES will include:

- Development of interactive, decentralized, scalable computing infrastructures, coupled with access to the huge amounts of data, available from the PNS.
- Flexible combination of different types of models, e.g. finite automata-like agents and complex agents, across different temporal and spatial scales,
- Easy for non-programmers to use, without introducing explicit choices about algorithms, data sources and optimising execution.
- Interactive exploration of data, requiring new methods of visualisation and interaction with planetary-scale data.

- Obtaining feedback from users through validated, structured processes, i.e. present findings to policy-makers, citizens and businesspeople, and incorporate their feedback to achieve continuous improvements.

Challenges in building the Global Participatory Platform
Presenting the data and making the system transparent to the user will require major advances in Visualisation Technology, Visual Analytics, and Human Computer Interaction. Coupling the models to real-world data, aiming for a real-time, interactive visualisation, and flexible combination of different modelling approaches represents a major paradigm shift. So does the embedding of the models into a public participatory platform on which developers unfamiliar with complexity theory and social science can quickly implement applications in a simple, problem-oriented way. Involvement of the general public will be enabled, for example, through crowd-sourcing, massive serious multi-player online games, and e-Governance applications. Complexity scientists must also collaborate with ICT researchers to ensure that the dynamics of interactions between models and data produce simulations corresponding to the expectations of the user, and to provide the user with information about the uncertainties and reliability of various results coming from competing models.

Challenges in Building Socially-inspired ICT
Models of the structure and dynamics of human societies will be used to inspire new kinds of ICT systems, that will be self-organizing, more stable and more trustworthy. The ICT systems must be designed in ways that **maintain socio-diversity** and avoid undesirable and unstable collective behaviours.

Challenges in Building the Innovation Accelerator
We will have the capacity to make rapid progress, even in highly specialised fields, by leveraging global expertise and experience through crowd wisdom, but interdisciplinary research on identifying, developing and motivating human expertise will be needed that can factor in many aspects such as diverse types of incentives; bounded human rationality; and human heuristics in the design of supporting Information Infrastructures. The vision of the Innovation Accelerator will require a continually extending social science, through synthesis with Complexity Science and ICT. Applying this science to meet ever-changing educational, personal and social objectives will help us to understand how individuals and groups synthesize beliefs, prior knowledge and observation to learn and remember, while designing, creating, managing and controlling systems adapted to ever-changing socio-physical environments.

Challenges in developing a new Global Systems Science
To deliver a new science of Global Systems, we will need to develop tools and techniques to manage vast technical datasets, combined with better modelling of human systems. On one hand, the development of tools to manage massive and highly heterogeneous and distributed datasets will be needed, and on the other technical systems that respect the special characteristics of people, including their capacity for reflection, innovation, and cooperation, and their desire to participate in social, economic and political affairs. Thus, we will need novel algorithms and new conceptual paradigms, to support and enabe the world's citizens make better-informed decisions.

Challenges in building the Observatories and Exploratories
The Exploratories and Observatories will face their separate and distinct technicalChallenges, as well as theChallenges of integrating, as far as possible, the data models, simulation tools and presentation routes. However, they will all face in some way the challenge of modelling and integrating agent and social models, at many scales and with sophisticated models of agents' cognitive behaviour and responses. For example, the Health and Epidemics Observatory will be challenged by the social response to its predictions, i.e. will need to define, test and validate behaviour-contagion models able to close the feedback loop between behavioural changes in the population in response to the actual disease impact. This would require a breakthrough in novel experimental behavioural science and cognitive science models, as well as the exploitation of novel experimental capabilities through a sensing and monitoring infrastructure, along with

secondary and proxy data harvesting. The Social Challenges Observatory will also face the issue of social feedback, since this Observatory will need to model people's reactions to policies and other measures of prevention, in the struggles against critical social phenomena. The Smart Cities Observatory is facing the challenge of developing a city simulation that integrates multiple systems and their data, while meeting appropriate confidentiality and privacy standards, and enabling citizens to participate in routine as well as strategic ways using these tools to enhance their quality of life.

Challenges in developing Ethical and Value-Sensitive ICT
The mainChallenges here are moral concerns about privacy, trust, and identity. Advanced computing for social sciences requires among other things conceptual clarity and technical translations of the concept of (i) informed consent and control over identity and identification, (ii) the right to be forgotten, (iii) contextual integrity of personal data, (iv) personal data. The technical Challenges will be the development of logics and formal languages enabling the perspicuous representation and implementation of machine readable moral principles and policies. The breakthrough required would be a framework for systematic, sustained and seamless collaboration between software engineers, information architects, hardware and database specialists, ethicists, legal scholars and social scientists on the articulation of moral principles of a fair and just information society and their effective implementation.

2.7 Metrics proposed to measure progress in FuturICT

The real value of FuturICT will be measured in terms of systems, technologies and methods that face towards society and how these systems, technologies and methods have a direct impact on society. This impact will be monitored and assess in the most quantifiable and measurable way possible.

FuturICT will produce scientific output, in the form of papers, journal articles, books etc., and we will commit to a quantified output in these areas. For each scientific subfield of FuturICT we will draw up a list of top-rated venues (top conferences and journals, depending on the publication culture per field). We will also identify the highest quality publication and dissemination outlets for interdisciplinary research and notify the FuturICT community of these venues.

- Number of papers, articles in top-rated journals
- Number of interdisciplinary papers, articles
- Number of books, book chapters, new journals etc

Metrics will continue to be used to measure uptake of FuturICT ideas by the press and general media. We will continue to distribute material through our website and social media, and will continue to gather statistics on the uptake of FurutICT keywords and novel concepts in the press, social media and publications. Some indicative metircs are below.

- Number of hits and new visitors to FuturICT website
- Number of mentions of FuturICT novel concepts in social media, e.g. blogs, tweets, Facebook, other sites
- Number of followers and likes on Twitter, Facebook etc.
- Number of articles and mentions in the printed media, television and radio

FuturICT will also monitor its impact on economic development by measuring the output of patents, licences, start-up companies etc. The number of meetings by scientists and administrative staff with businesspeople, and presentations to companies will be monitored.

- Number of patents, licences, start-ups and business collaborations

- Number of standard contributions, software reference implementations, open source contributions/releases
- Number of meetings with businesspeople and FuturICT scientists or administrative personnel
- Number of FuturICT apps in the FuturICT GPP application store, number of developers in the FuturICT GPP developer network
- Number of data sources, models, and algorithms hosted by and accessible via FuturICT to customers/producers/prosumers in society
- Number of presentations at industry and company events.

FuturICT will continue to develop its work on integration of the sciences of EICT, complexity science and social science. We will measure the number of workshops and exchange visits, and the number of interdisciplinary case studies and use cases that are available and have been employed.

- Number of interdisciplinary workshops organized by or attended by FuturICT personnel
- Number of exchange visits between FuturICT personnel and to other research or industry institutions or laboratories.

We do not want to over-burden the scientific and administrative personnel of FuturICT with too many metrics that are difficult to obtain and collate, so we focus on metrics that will be accurate and verifiable.

Overall metrics will include:

- Number of papers per € 1M,
- Number of patents per € 10M,
- Number of licences per € 10M,
- Number of start-ups per € 10M,

The progress of the Flagship towards delivery of the high level Objectives will be measured using success criteria for the Focus Areas, and specific detailed objectives for each of the Workpackages within the Focus Areas. The metrics for both the high level Objectives and the workpackages will be refined and adjusted during the run-up to delivery of the proposal document. Below we give the Success Criteria for the Focus Areas.

FA1: Success Criteria for the Planetary Nervous System
Being able to measure various social factors globally and in real time, such as social well-being and social capital.

FA2: Success Criteria for the Living Earth Simulator
Establishment of an Open World of Modelling Platform; a financial market smulations; a more resilient financial architecture.

FA3: Success criteria for the Global Participatory Platform
A simple platform usable by everyone; a brokerage platform; an open educational platform.

FA4: Success Criteria for Socio-Inspired ICT
Novel design and operation principles for self-organizing, trustworthy, reliable and open global ICT systems, promoting responsible use.

FA5: Success Criteria for an Innovation Accelerator
Better indices to measure scientific value generation, number of spin-offs.

FA6: Success Criteria for a Global Systems Science
Better understanding of systemic risks, models to decribe how the interaction of information sparks off new trends, efficient methods to model and simulate real-world complex systems

FA7: Success Criteria for Interfaces, Standards and Systems Integration
Identification and classification of relevant standards organisation and industry forums; alignment of the FuturICT platform with relevant standards; contributions to relevant standards by means of FuturICT innovations; specifications and reference implementations
FA8: Success Criteria for the Creation of Exploratories
Integration of data models and interctivity, e.g. new platform for behavioural experiments and simulation.
FA9: Success Criteria for Ethical and Value-Sensitive ICT
Development of principles of privacy-respecting data mining and of value-senstive ICT that promotes responsible use; public ethical debate about challenges of Big Data and the Information Age

2.8 Coordination of activities and research communities

Integration of disciplines
The FuturICT Flagship project will build on the extensive network of expertise of the scientists who have been associated with, and have contributed to, the Pilot Phase. During this preliminary phase, we have already seen ICT becoming more socially-connected, social science becoming more computational, and complexity science helping us to understand connectivity.

The Focus Areas and Workpackages have been designed to enable interdisciplinary working in small teams. There will be support within each WP for travel and exchanges between WP members, including students. National and international FuturICT events have demonstrated with value throughout the CA Phase as a means to foster collaboration. Prizes, awards and new projects will encourage interdisciplinary working.

Structure, alignment and support of European communities and programmes
FuturICT is already aligned with the research priorities of the EU Horizon2020 Programme, such as the commitment to excellent science, making industry more competitive, and improving society. We will invite leaders of other major EU project to advise us by becoming members of the Strategy Board, or by aligning their projects with FuturICT and becoming involved at a technical level. A number of existing EU projects have already signed letters of support indicating their willingness to engage with FuturICT workpackages.

Structure, alignment and support of national communities and programmes National programmes will support FuturICT in a number of ways, as indicated by the Letters of Support at futurict.eu/the-project/whos-involved. Ireland has agreed to lead the ERA-NET+ that will help to align and integrate the funding from consortium member nations. We will be closely aligned with the national agencies through the Coordination and Engagement Team, which will have one representative from each of the countries that are members of the FuturICT Consortium, or wish to become members.

Structure, alignment and support of international communities and programmes FuturICT has already established links wtih communities in the USA, Australia, Singapore, China and Japan. We will seek to exchange visitors, conference invitations, and link to each other's websites. Prof Sandy Pentland's Media Lab at MIT will be closely associated with the work of FuturICT, which will give European research an important profile in North America.

Section 3

Implementation

3.1 Governance and Scientific Leadership

The goals of the governance and legal structures of the FuturICT project are:

- to support the scientific endeavours of FuturICT and ensure that its goals are realised,
- to enable opportunities for innovation and collaboration within the FuturICT community,
- to ensure that the outcomes of the research work make the most effective contribution to the creation of wealth and social benefit within Europe, and
- to do so in a way that is demonstrably ethical, legal and fair.

Scientific projects of the scale of FET Flagships face a number of generic challenges, as well as those specific to Big Science projects. Following established practice for major projects, FuturICT has established and promoted a clear long-term visionary goal; has established an accepted and flexible governance framework; has adopted procedures for project management and communication; has built a community; and has developed practical, effective and ethical guidelines for the conduct, dissemination and practice of its work. Furthermore, the familiar administrative disciplines and procedures of FP7 will provide managerial consistency and help to overcome what could be otherwise be a set of very nation-specific, complex management processes. During the CA phase of the project, the scientific and management teams at ETH and UCL have worked closely together, developing and establishing working practices and processes that will enable us to continue to collaborate effecitvely over the next 10 years.

The focus of the FuturICT governance structure is the scientific management of the work-packages within the Focus Areas, with professional support of monitoring, recording, communication and dissemination. The two principal committees are the **Strategy Board** and the **Executive Board**, with the voting members of both committees being principally scientists. In order to ensure that the FuturICT achieves and maintains excellent science, there will be **Science Board** with the role of integrating the scientific ideas, projects, initiatives and proposals that emerge from FuturICT and aligned projects going forwards. Meetings will be attended by members of the professionally-staffed **Project Office**. EU citizens, businesspeople and distinguished scientists will contribute to FuturICT through advisory and representative panels. The governance structure is already in place and has been active during the CA phase of the project; it is robust and well-practised, and will remain active and continue to develop until the FP7 phase of the project begins, as well as providing the flexibility to enable further transition to the Horizon 2020 phase.

Governance structure
The design of FuturICT's governance structure is based on the principles advocated by the literature and practice of managing large projects and programmes, tempered with the advice from scientists who

manage other large projects that share many of the organisational challenges that FuturICT will face, e.g. CERN and the ATLAS experiment. The structure is also consistent with that often used for large EU projects.

A guiding principle in the design of the governance of FuturICT is the **separation of policy and implementation**, as is the case in other Big Science projects, such as ATLAS. The level of setting strategic policy will be distinct from the operational level, although both will be informed by the other, since issues of cost, timeliness and legal and ethical constraints will apply, will be understood and will be clearly communicated throughout the governance and management structure. The distinction between strategy and operations will be enforced by a **Strategy Board** that sets policy, an **Executive Board** that oversees the implementation and operation of the Focus Areas and workpackages, and a **Council of Partners** that will ensure that operations are compliant with the operational requirements of the grants and funding arrangements.

A second guiding principle of the governance of FuturICT is **to ensure the fruitful integration of the three scientific disciplines** on which FuturICT is built. In other words, we must avoid people becoming silo-ed or retreating back into their home institutions or disciplines. Rather, we have built the governance structure upon the model of the FuturICT community as an active network of collaborators who may be involved in more than one workpackage at any time, so that the workpackages are delivered by flexible teams of researchers, interacting and directed towards a particular goal. The governance structure will ensure that each scientific discipline is fairly represented in the decision-making structure.

There will be a series of intensive annual one-week meetings, the **FuturICT Weeks**, which will bring together the extended FuturICT community to present findings, form collaborations and meet sponsors. These week-long events will host international special-interest conferences and workshops; hold public demonstrations and showcase events suitable for children and members of the public; convene a plenary session of the FuturICT assembly; present ideas festivals to funding and investment organisations and business developers; and hold training and networking events for special interest groups within the scientific community, such as minorities, women and developing economies.

The key committees of the structure explained below have been in place since Summer 2011, so that colleagues have experienced the roles, responsibilities and practicalities of a formal governance model. New members continue to accept invitations to serve on the committees, so that the full committee structure will be in place when the FuturICT project begins in 2013.

The governance structure is shown in Figure 3.1.

Strategy Board (SB)

At the top of the governance structure will be a **Strategy Board** that will provide strong scientific leadership and set the strategic direction and objectives of the FuturICT project. The realisation of this vision should bring about *tangible benefits* to European society, European science and European competitiveness. The *strategic vision* will be developed and maintained with the input of various stakeholders, as represented in the **FuturICT Advisory Boards**. It is the responsibility of the Strategy Board to appoint, consult and disband these groups as appropriate, with practical support from the **Coordination and Engagement Team**.

FuturICT's *strategic vision* has been formulated and defined, and has been mapped onto a series of *strategic objectives*, which will be the overall objectives of the FuturICT project. These strategic objectives should remain relatively high-level rather than specific, but their achievement and their subsequent tangible benefits should be verifiable by the FuturICT Strategy Board by tangible indicators. A final role of the FuturICT Strategy Board is to champion the project and its *strategic vision* amongst the scientific communities, with the objective of securing scientific support. The minutes of the FuturICT Strategy Board will be provided to the FuturICT Executive Board.

The FuturICT Strategy Board will:

- Initially be chaired by Professor Dirk Helbing. The Chair will hold primary responsibility for champi-

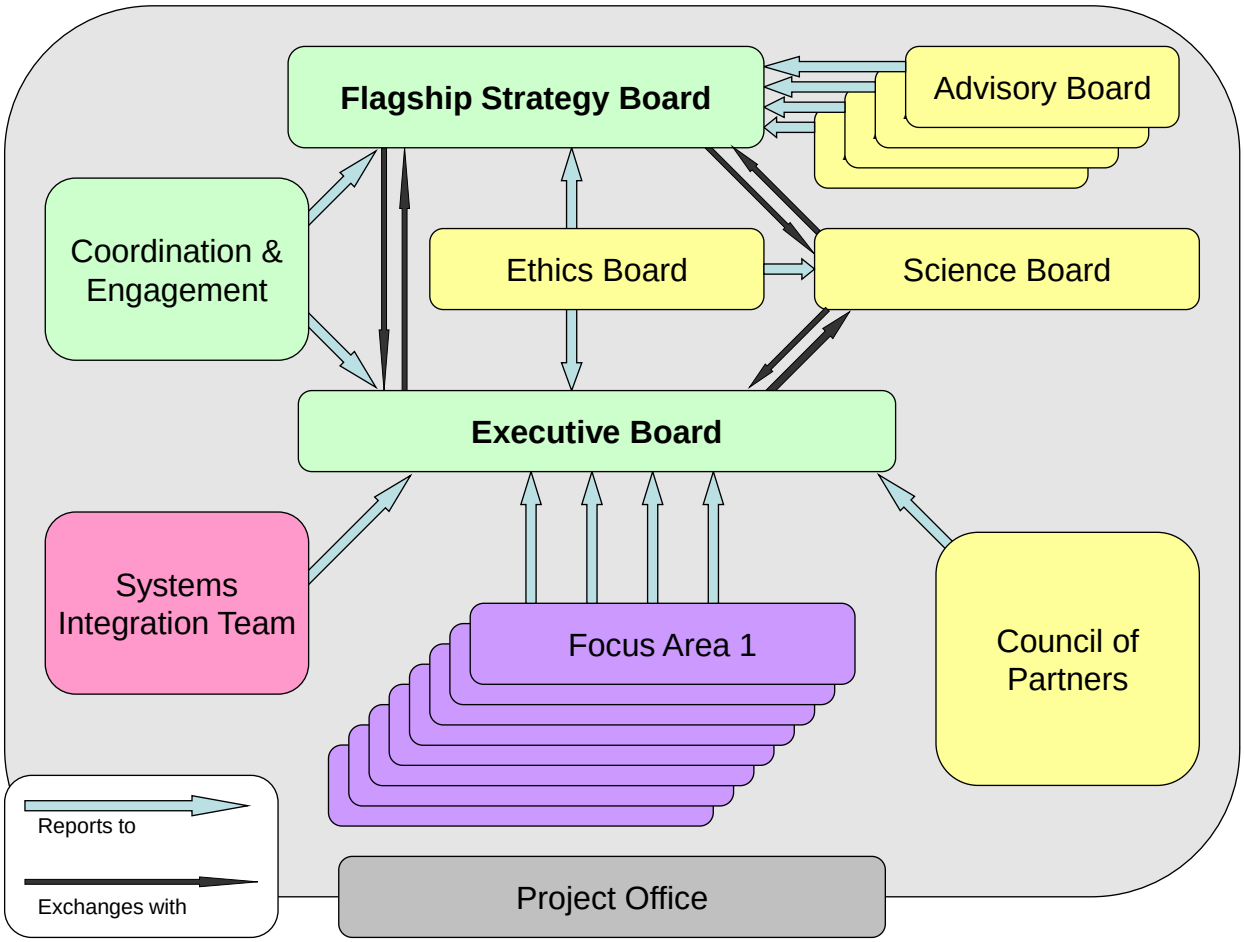

Figure 3.1: FuturICT governance structure

oning the project and its Strategic Vision amongst the scientific communities, and for coordinating the FuturICT Advisory Boards. Subsequent Chairs will be elected biannually.

- Include a number of leading international scientific figures as full members. This will include experts in the three areas of basic research, applied research and innovation, and the three principal scientific foundational areas of FuturICT.
- Include Professor Steven Bishop (as the Chair of the FuturICT Executive Board and non-voting member), who will hold primary responsibility for ensuring that the proposed Strategic Objectives are likely to be feasible with regards to external operational, political and resource constraints.
- Initially include Martin Scott (as the FuturICT Project Manager) as a non-voting observer, who will advise the Board on whether the proposed Strategic Objectives are likely to be feasible with regards to the contractual constraints. In this regard, the FuturICT Project Manager also acts as the non-voting representative of the FuturICT Council of Partners.
- Include some representatives of universities or other institutions that have made significant financial support to the FuturICT consortium.
- Include a senior representative of the European Commission as a full member, who will be expected to attend the meetings.
- Include selected representatives of major project funders and business partners as full members.
- Include a representative of the Ethics Board as a full member, with specific veto powers with respect to ethical issues.
- Can call meetings of the Advisory Boards as needed
- Will publish agendas and minutes of meetings on the FuturICT website.

Further details on the committees may be found in Table 3.1 and Figure 3.1.

FuturICT Science Board (SB)
The FuturICT Science Board will provide a forum for members of the FuturICT consortium to discuss the scientific ideas, concepts, discoveries and scientific outcomes of the project, in order to ensure integration of the scientific disciplines and to promote awareness of the activities of the Focus Areas and Workpackages within the project. Membership will be open to Focus Area leaders, Workpackage leaders and leaders of other projects aligned to FuturICT. The Board will identify ideas for further projects, whether undertaken with FuturICT or requiring application for funding from other sources. Initially, the Chair will be Prof Dirk Helbing.

FuturICT Executive Board (EB)
The FuturICT Executive Board's primary responsibility is to translate the Strategic Objectives developed by the FuturICT Strategy Board into a series of *Concrete Targets*, and to identify and obtain the human, financial and other resources required to achieve these targets.

The primary tool available to the FuturICT Executive Board is the implementation and modification of the nine scientific FuturICT Focus Areas, each led by a FuturICT Principal Investigator. Where sufficient expertise or resource may become unavailable within the project, it is also the task of the FuturICT Executive Board to identify where these might be found, with the support of the Coordination and Engagement Team and following the advice of key stakeholders as represented by the FuturICT Advisory Boards.

The FuturICT Executive Board is therefore tasked with the coordination of the project's work, via the development and monitoring of the Concrete Targets attributed to each of the FuturICT Focus Areas, in

Board or Committee	Frequency of meetings	Voting members	Non-voting members	Term of membership	Quorum
Strategy Board (SB)	Twice per year during ramp-up phase, including FuturICT Week.	Chair; Chair of Management Committee; Nominated member of EU; Chairs of Advisory Boards; Chairs of Representative panels; Leading scientific figures	PO Leader	*Ex officio* for chairs. Two years, renewable for two more	Half + 1 of the voting members
Executive Board (EB)	Once a month via video-conference + FuturICT Week; more often during ramp-up phase	Chair of EB; Focus Area Leaders or their deputies	PO Leader	*Ex officio*	Half + 1 of the voting members
Science Board	2-4 times per year inc. FuturICT Week	No more than 20	n/a	Two years, renewable for two	n/a
Ethics Board	2-4 times per year inc. FuturICT Week	No more than 15	n/a	Two years, renewable for two	Three voting members
Science Advisory Board/ FuturICT Ambassadors	Twice per year inc. FuturICT Week	No more than 25, including co-opted members from WPs	n/a	Two years, renewable for two	Three voting members
Innovation Advisory Board	Twice per year inc. FuturICT Week	No more than 15	PO Leader	Two years, renewable for two	Three voting members
Awards Board	Twice per year inc. FuturICT Week	No more than 15, including 1 SB member	n/a	Two years, renewable for two	Three voting members
Users' Representative Group	Once per year during FuturICT Week	No more than 15	n/a	Two years, renewable for one	Three voting members
Funders' Panel	Once per year during FuturICT Week	One representative from each of the funding organisations	PO Leader; 1 SB Member	Two years, renewable for one; *Ex officio*	Half + 1 of voting members
Systems integration Team	Once a month via video-conference + FuturICT Week; more often during ramp-up phase	One representative from each of the Observatories and ICT-heavy FAs/WPs	PO leader	*Ex officio*	Half + 1 of voting members

Table 3.1: Details on frequency of meetings of FuturICT Boards and Committees

order to eventually achieve the project's Strategic Objectives. These Concrete Targets, along with the financial, temporal and other constraints attributed to Focus Areas will be formalised via a series of agreed Focus Area Plans.

Specifically, the FuturICT Executive Board will:

- Monitor the proper execution and implementation of the project and its individual Focus Areas, including the collection of information from the individual Work Packages and each of the Participating Institutions;
- Translate the Strategic Objectives set by the FuturICT Strategy Board into Concrete Targets, to be implemented within each Focus Area via changes to the Focus Area Plans.
- Make any subsequent necessary change requests to the Council of Partners for changes to the Framework Programme 7 and/or Horizon 2020 Grant Agreement/s, changes to the project's core Consortium Agreement or the declaration of any Participating Institutions to be formally in breach of their obligations
- Regularly report to the FuturICT Strategy Board and the Ethics Board on project progress and planned activities.
- Mediate and resolve where possible any disputes between the participants relating to the implementation of the project, and forward details of any disputes that cannot be resolved except via contractual means to the Council of Partners.

A final role of the FuturICT Executive Board is to champion the project and its Concrete Targets amongst the political, social and business communities, with the objective of securing financial support.

The FuturICT Executive Board will:

- Initially be chaired by Professor Steven Bishop, who will hold primary responsibility for championing the project and its concrete targets amongst the political, social and business communities, and for coordinating the FuturICT Implementation Advisory Boards. Subsequent Chairs will be elected biannually.
- Include each of the FuturICT Focus Area Leaders as full members, each of whom will also represent the interests of their Focus Area. The membership of the Committee will therefore evolve as FuturICT Focus Areas are commissioned, expanded and/or terminated.
- Initially include Martin Scott (as the FuturICT Project Manager) as a full member, who will advise the Board on whether the proposed Strategic Objectives are likely to be feasible with regards to the contractual constraints. In this regard, the FuturICT Project Manager also acts as the non-voting representative of the FuturICT Council of Partners.
- Include a representative of the EU as a non-voting member, who will be expected to attend every meeting.
- Include a member of the Strategy Board as non-voting advisor and observer
- Include other representatives from the Project Office as non-voting observers, who will advise the Executive Board on whether the developed concrete targets are likely to be feasible with regards to specific financial, legal or administrative constraints.
- Include both the Chair and Vice-Chair (appointed on a 6-monthly rotation) of the Coordination and Engagement Team as full members.

- Include a representative of the Ethics Board as a full member, with specific veto powers with respect to ethical issues.
- Include representatives of other Advisory Boards, as necessary.
- Include leaders of FuturICT Work Packages to address specific issues, from time to time as needed.

FuturICT Focus Area Leaders

The primary responsibility of the FuturICT Focus Area Leaders is to achieve their allocated Concrete Target(s) through the coordination of the Focus Area for which they are responsible, within the boundaries imposed by the FuturICT Executive Board. This will be achieved through the management of their own Participating Organisation's contribution, the management of contributions from any other Participating Organisations involved in their Focus Area and the identification and coordination of any necessary contributions from third-party organisations.

As such, the FuturICT Focus Area Leaders are tasked with the actual implementation of the project, via the use of Tasks, Deliverables and Milestones attributed to their Focus Area participants, and via the sub-division of the financial, temporal and other boundaries imposed by the FuturICT Executive Board between these Focus Area participants. FuturICT Focus Area Leaders are also ultimately responsible for the quality of work delivered by Focus Area participants, and for liaising with stakeholders specifically related to their Focus Area. The primary tool that the FuturICT Focus Area Leaders will use in carrying out their role will be a Focus Area Plan, constituted of detailed plans covering each of the Work Packages within his or her allotted Focus Area.

FuturICT Focus Area Leaders will be encouraged to employ a scientific manager to assist them, and to use generally accepted project management methodologies to ensure that their Focus Area successfully achieves its concrete targets within the given constraints. It will be their responsibility to monitor and track progress on their Concrete Targets; maintain their website of events, publications and other outputs; and contribute to the maintenance of the central database of FuturICT supporters, stakeholders and contributors.

Focus Area Leaders should expect to spend around 20% of their time on managing their Focus Area and attending meetings. Where they are unable to fulfil their management commitments to FuturICT, the Focus Area Leader should nominate a replacement. Exceptionally, the Executive Board may write to the Focus Area Leader to ask them to nominate a replacement where the satisfactory progress of the Focus Areas and Work Packages are being put at risk.

Council of Partners

The Council of Partners is a formal grouping of the Participating Institutions who are the formal beneficiaries of the Framework Programme 7 (and later the Horizon 2020) Grant Agreement for the core FuturICT project. This group will therefore hold overall responsibility for the interpretation and implementation of the Grant Agreement, and each Participating Institution will therefore submit one duly authorised representative to sit on the Council of Partners. Each representative will have one vote. The Project Office will send non-voting members to meetings of the Council of Partners, and the EU will be invited to send non-voting observers.

Based on the parameters set by the decisions of the FuturICT Strategy Board and the FuturICT Executive Board and with the support of the FuturICT Project Manager, the Council of Partners is responsible for formally implementing the following contractual procedures:

- Agreeing upon the project's core Consortium Agreement.
- Submitting proposals to the European Commission in respect of amendments to the FP7 and/or Horizon 2020 Grant Agreements, including changes to the work to be carried out and the assigned budgets per Participating Institution.

- Submitting proposals to all of the Participating Institutions with respect to changes to their contractual rights and obligations (thus necessitating an amendment to the core Consortium Agreement).
- Agreeing to declare Participating Institutions to be in breach of their obligations, and setting remedies and sanctions as necessary.
- Formulating changes with respect to formal Intellectual Property and confidentiality rights and obligations.

The Council of Partners, representing the contractually bound Participating Institutions, can therefore be considered the highest authority in the project with respect to issues pertaining to the signed Grant Agreements. The Council of Partners will, however, only act in a reactive mode, by responding to change requests.The Council of Partners will report to the Executive Board, and receive minutes from the Executive Board and Strategy Board.

Core Management Team
The FuturICT Core Management Team will be responsible for coordinating the day-to-day implementation of the project via their mandates received from their respective governance bodies (thus representing a 'cabinet-style' team). The FuturICT Core Management Team will be a closely knit group that, while having no formal decision-making power as a separate body in its own right, will be crucial to the smooth functioning of the overall FuturICT governance structure as facilitators and project coordinators.

The FuturICT Core Management Team will:

- Include the Chair or a representative of the FuturICT Strategy Board
- Include the Chair or a representative of the FuturICT Executive Board
- Include the Coordinator of the Coordination and Engagement Team
- Include the Leader of the Systems Integration Team
- Include the FuturICT Project Manager (also representing the Council of Partners)
- Be provided with secretarial support by the Project Office

FuturICT Project Office
The Project Office (PO) will provide the FuturICT project consortium with a competent, professionally-qualified and experienced team of full-time individuals to provide a stable and professional management support service to the FuturICT project, in order to ensure that it is effectively, efficiently and transparently implemented in accordance with all relevant laws, conventions and procedures. Led by the FuturICT Project Manager, the FuturICT Project Office is responsible for a number of duties in support of the FuturICT project. These include:

- Liaising with the Participating Institutions (collectively the Council of Partners) on financial, contractual and administrative matters.
- Financial planning, management, accounting and budgetary control, to ensure effective and efficient use of FuturICT's financial resources;
- Liaising with the FuturICT Executive Board in the management and administration of the day-to-day activities of the project, including maintaining databases of contact details, strategic objectives, concrete targets, tangible benefits, tasks, deliverables and milestones.
- Providing support to the Strategy Board on request,

- Taking, storing and circulating minutes of the project's various governing bodies.
- Resolving issues and initiating corrective action.
- Managing the project's resources budget and monitoring its expenditures against the Tangible Benefits that are realised as the project progresses.
- Managing third-party contributions to the project, including assistance with drawing up necessary agreements and contracts.
- Facilitating the appointment of individuals to the Focus Area teams.
- Ensuring maximum efficiency in the allocation of resources and skills, thus providing financial added value.
- Providing training and support materials to Focus Area Leaders and workpackage leaders in project management.
- Assisting with the efficient acquisition of other resources by maintaining relationships with external organisations, for example contracts agencies, travel agents, events organisers and equipment/premises rental companies.

The now extensive list of FuturICT Project Office functions has been fully rationalised by translating it into a number of key roles required to effectively deliver a professional and modern project support service. This system conforms to the well-established and proven guidelines laid out in the UK Office of Government Commerce's 'Managing Successful Programmes' methodology, with the role-centric system allowing for maximum flexibility, as well as clear lines of responsibility and authority. For example, it is anticipated that during the 'ramp-up' phase of the FuturICT project a single expert may be able to fulfil more than one of these roles, whereas in the later stages of the flagship a particularly critical role may even require more than one person to fulfil it. Specific roles of the FuturICT Project Office will include:

- PO: Overall leadership of the FuturICT Project Office (FuturICT Project Manager)
- PO-R: Overall management of FuturICT's resources, PO-R1: Planning, costing and budgeting of FuturICT's financial resources, PO-R2: Financial accounting, analysis and auditing of FuturICT's expenditure, PO-R3: Coordination, transfer and accounting of incoming and outgoing funds, PO-R4: Management of FuturICT's human resources (recruitment, contracts & scheduling).
- PO-C: Coordination support for the FuturICT project, PO-C1: Coordination and tracking of FuturICT reports, deliverables and milestones, PO-C2: Tracking and management of project risks and issues, PO-C3: Tracking of FuturICT's human resources (work, skills, responsibilities & availability), PO-C4: Organisation of FuturICT events, travel and accommodation requirements.
- PO-L: Legal and contractual support for the FuturICT project, PO-L1: Drafting, negotiation and conclusion of FuturICT's contracts and agreements, PO-L2: Development and management of FuturICT's patent and license portfolio, PO-L3: Provision of expertise concerning the FP7/EU aspects of the FuturICT project, PO-L4: Drawing up ethical guidelines, scheduling training courses and maintaining register of ethical compliance for projects and personnel. PO-L5: Identification and preparation of training courses and materials; scheduling and publicising training courses.
- PO-X: External relations support for the FuturICT project, PO-X1: Support for liaison with stakeholders and outside organisations including the EU, PO-X2: Updating of the FuturICT websites, news channels and online forums, PO-X3: Management of FuturICT's media relationships and public image, PO-X4: Coordination and transmission of FuturICT's publications and publicity materials, PO-X5: Event organisation and publicity, including FuturICT Weeks.

- PO-T: Technology transfer support for the FuturICT Innovation Accelerator, PO-T1: Identification and monitoring of potentially valuable FuturICT foreground, PO-T2: Liaison and negotiation with purchasers or licensees of FuturICT foreground.
- PO-I: IT support for the FuturICT project (also reporting to the System Design Board), PO-I1: Setup and coordination of FuturICT management and communication IT systems, PO-I2: Maintenance of data protection and IT security protocols and software within the FuturICT project.
- PO-S: Secretarial and administrative support PO-S1: Secretarial and administrative support for the FuturICT Core Management team and Boards, including maintaining contact lists, PO-S2: Secretarial and administrative support for the Project Office and its members.

The current balance of workload between ETH and UCL is that UCL leads the PO and oversees the Resouces, Legal and Secretarial functions, and provides administrative support to Prof Bishop. ETH provides Coordination support, Public Relations, Events Management and administrative support to Prof Helbing.

FuturICT Ethics Board

The FuturICT Ethics Board is responsible for ensuring that the project is carried out within the accepted ethical practices of the participating partners, and retains the power to veto any decisions of the FuturICT Strategy Board and FuturICT Executive Board that may contravene ethical considerations. As such, the FuturICT Ethics Board can be considered the highest authority in the project with respect to issues falling under the scope of ethics. The FuturICT Ethics Board is chaired by Prof Dr Jeroen Van den Hoven (University of Delft) and will consist of world-renowned experts in the field of ethics.

The responsibilities of the Ethics Advisory Board are to draw up and maintain a policy on ethics, which will be featured prominently on the FuturICT website; to advise on ethical questions that arise from the research that is being conducted or proposed; to respond to issues referred to them by any committees or researchers of FuturICT; and to recommend alliances and concertation with other projects. A training pack will be available with all Calls for Proposals, and workshops and training courses will be provided on-line or in person at participants' sites.

The FuturICT Ethics Board will receive the agendas and minutes of the FuturICT Strategy Board and the FuturICT Executive Board, and will also be represented via the inclusion of a full voting member in each (with subsequent immediate powers of veto). The Ethics Board will report to the Executive Board and the Strategy Board. The FuturICT Ethics Board will also have direct access to the Project Risk Register, duly updated by every single member of the FuturICT collaboration.

The point of contrast between the FuturICT Ethics Board and the FuturICT Ethics Focus Area is that the FuturICT Ethics Board acts as a 'fail-safe' or 'fusebox' to prevent the project from falling into ethical difficulties, whereas the Ethics Focus Area is responsible for developing new ideas and procedures in the field of ethics to support FuturICT's novel Big Science agenda.

FuturICT Advisory Boards

The FuturICT Advisory Boards are appointed, constituted and disbanded by the FuturICT Strategy Board. The FuturICT Strategy Board will delegate matters relating to the organisation and implementation of these groups to the Coordination and Engagement Team, with administrative support from the FuturICT Project Office. These groups are constituted either of stakeholders who have a stake in the project's Tangible Benefits, or leading figures with expert knowledge of a particular area. The initial FuturICT Advisory Boards will be:

- **FuturICT Ambassadors**: Extremely highly respected scientists who will not have direct responsibility for project strategy or implementation, but will champion the project and build its reputation.
- **Board of National Coordinators**: Representatives of the national funding agencies and the aligned ERA-Net Plus will provide advice to the FuturICT governing bodies.

- **Innovation Board**: Participating Institutions' Technology Transfer Office representatives
- **User Representative Groups**: Consisting of ad-hoc focus groups of citizens, scientists, policymakers and/or business users. These groups are convened in order to make sure that the user experience for each of these groups is appropriate, and that the project's outputs remain in line with their requirements. These groups are convened at the request of the FuturICT Strategy Board, with the members coordinated via the Coordination and Engagement Team.
- **Awards Board**: The body responsible for the fair and transparent award of grants and prizes within the scope of the FuturICT Open Calls.

In order to provide transparency on financial management, the **Awards Board** will provide a separation between the Strategy and Executive Boards and the discretionary award of funds. The Awards Board will receive a recommendation from the Strategy Board for a call for proposals or award of prizes, write the call and devise acceptance criteria, timelines etc. Where awards may be offered for special achievements, the criteria will be established, and timelines agreed. The procedures and schedule proposed by the Awards Board will be passed to the Project Office for implementation and the Executive Board will be informed. In this way, the activities of policy-setting and implementation are kept entirely separate. Although calls for proposals and prizes are issued by the Strategy Board, they are specified by the Awards Board, and carried out by the Project Office. This ensures a clear line of control and responsibility, and enables transparency through an open audit trail.

The **Coordination and Engagement Team** will be constituted of representatives of each of the countries participating in FuturICT. Its primary responsibility is to identify and engage with scientific groups, institutions, funding agencies and businesses within each representative's country. As such the Coordination Team interfaces primarily with the FuturICT Executive Board and is facilitated in this task primarily and initially by Professor Steven Bishop. However, the FuturICT Strategy Board may also provide input, particularly in the areas of stakeholder identification and engagement.

Systems Integration Team (SIT): ICT will be a central and hugely significant part of FuturICT, and it is important that it is given due prominence, especially during the early stages when hardware, data structures and software will be specified and procured. The integration of the ICT systems across multiple sites and pre-existing projects is crucially important to the future success of this project. Thus, we include a Systems Integration Team with specific remit to oversee the design and management of ICT systems. This team will be supported by the principal functions from the Project Office, and will work closely with the chair of the Executive Board. The leader of the Systems Integration Team will be one of the key decision-makers in the FuturICT's coordinating team. The members of the SIT will be the leaders (or their deputies) of all the Workgroups and Workpackages that have a significant responsibility for ICT design, implementation or expenditure. The leader of the SIT will be Thomas Bohnert (ZHAW, Switzerland), who is Focus Area Leader of FA 7: Systems, Standards and Integration, and an expert on "'The Future Internet"' and other ICT-intensive EU projects.

The **FuturICT Foundation** will be a charitable foundation, likely based in Belgium, which will receive, manage and distribute charitable donations from individuals, corporations and other foundations. This money will be used to support research initiatives associated with FuturICT. FuturICT donors will be invited to the FuturICT Week, and to view demonstrations of deliverables and outcomes.

The proposed governance structure may be amended from time to time as FuturICT develops, in response to changes in funding, technology, leadership and legislation, for example. In particular, although FuturICT is beginning during the FP7 regime, it is not possible at this time to know what the legal and governance requirements of the upcoming Horizon 2020 Programme will be, so we must be able to amend the governance in response to these requirements as they become clearer.

3.2 Goals and values of governance

The leadership culture of the FuturICT project will set out a clear vision that will empower and enable team members; support interaction with the internal and external project stakeholders; create a culture of trust and ethical behaviour, and take ultimate responsibility for the outcomes of the project.

Transparent, auditable, open, inclusive, ethical, flexible
Ethical behaviour and practice is at the heart of FuturICT. The **Ethics Board** held its first meeting in September 2011, chaired by Prof Jeroen Van Den Hoven (TU Delft). A research programme on Ethical and Responsible Research will be established, that will include collaborations and case studies of existing projects, whether within or beyond FuturICT.

The culture and practice of **transparency** will be evident through the publication of agendas and minutes of the principal boards and committees (e.g. Strategy, Executive and Council of Partners) on the FuturICT website. The committees with responsibility for awarding and allocating funds, the Awards Board and the Executive Board, are distinct from the Strategy Board, so that decisions on funding can only be made according to principles agreed by other committees. The Executive Board may make minor budgetary adjustments to active workpackages, within the constraints of the EU or other funding bodies, and will have to report and publish those decisions, as part of their minutes, on the FuturICT website. The Project Office will be staffed by professionally qualified people who are familiar with the EU's financial reporting discipline and practice, so that all documents are properly **maintained for audit**.

The rapid pace of technological change means that we must be alert to new possibilities, **flexible**, and **open to new ideas and new participants**. This will achieved through consultation with the representative panels; suggestions and proposals from within the community; and feedback during FuturICT Weeks. Open calls for proposals and open invitations to join FuturICT will be proposed from time to time by the Strategy Board, planned by the Awards Board, and the procedure managed by the Project Office. At present, we plan to make 5-10 M€ available in open calls through FA 12. In this way, there will be a fair and open procedure for people to join the consortium. There will also be mechanisms for applying for small grants through the FuturICT website, encouaging widespread deployment of small projects and initiatives suported by FuturICT. This will be particularly available to young researchers, including students and post-docs. The legal structures will remain flexible so that new participating organizations can be added to the FuturICT consortium once the project is in place.

The annual FuturICT Weeks will provide a public forum to showcase FuturICT's outputs and engage in public debate about the research directions, social impacts and ethical dimensions. Funding will be available to prepare public exhibitions, events, competitions and displays, particularly during FuturICT Week, and for locally initiated and organized events and hub activities throughout the year.

The project will promote **inclusion** by helping scientists with domestic or outside responsibilities to reach their potential. This will include such practical issues as scheduling meetings and events at family-friendly times, making use of effective live communications media, being aware of career breaks while assessing candidates, and avoiding tokenism. crech facilities and children's events will be provided during FuturICT Weeks to enable scientists with families to attend. Short courses and networking events will also be held during FuturICT Weeks. FuturICT has already demonstrated its commitment to furthering the careers and aspirations of early-career scientists by holding a Young Scientists session at ECCS 11 (European Conference on Complex Systems) in Vienna in September 2011.

Aware of challenges of managing a large multi-disciplinary, multi-national community.
The FuturICT project will establish a culture of effective, trusted communication in order to address the possibility of breaking up into isolated, poorly integrated project silos. Collaboration will be encouraged: by having each Focus Area to be led by scientists from all three disciplines; providing flexible funding to enable visits, exchanges and project workshops; awarding prizes at FuturICT Week for the best multi-disciplinary projects, publications and outputs; and making frequent and effective use of electronic communication

and report logging to maintain high levels of awareness within and between projects. FuturICT Weeks and meetings of the principal committees and boards will be held in different locations, beyond the project hubs of UCL and ETHZ. Each partner organization will be expected to work with their national funding agency to host an annual one-day event to bring together scientists from that nation so that they can present progress and findings. These may be combined with presentations and visits to local FuturICT projects, meetings with local national representatives, and the local national FuturICT day-long event where convenient. There could also be a job fair for young researchers, to meet colleagues from other universities, research institutes and businesses who are seeking to recruit. New businesses and start-ups can also meet with funding angels, supported by the local Technology Transfer Offices.

Decision-making power in the hands of scientists.
The principal committees, i.e. the Strategy Board and the Executive Board, are made up of scientists, advised by the professionally staffed Project Office. The Strategy Board will be made up of senior scientists from international, non-FuturICT projects and research institutes, as well as members of FuturICT. The Executive Board will be made up of the Focus Area leaders, and two non-voting members of the Project Office. Observers from the EU will be members of the Strategy Board and Exective Committee and will expected to attend meetings to ensure an effective working relationship and proper understanding of the management of a large project. The Science Board will focus on the science of FuturICT – improving the quality and scope of the scientific outputs of the project; seeking out new opportunities for collaboration, within and beyond Europe; exchanging and integrating scientific ideas, while the Executive Board manages the deliverables and progress of the Focus Areas and Workpackages. Project leadership and decision-making will be securely in the hands of scientists, who will be professionally supported in order to devote the maximum amount of time to work addressing FuturICT's scientific goals. Issues that cannot be resolved by the Executive Board will be escalated to the Strategy Board. If they cannot be resolved there, then they may be taken before the Council of Partners, which will be the ultimate body for resolving disputes and approving contractual amendments.

3.2.1 Integration

The focus of the integration activities will be on the sharing of Workpackages and Focus Areas across national boundaries, while making use of the top scientific expertise and providing training and support for young researchers. The ERA-NET Plus Steering Group will meet during the FuturICT Week, and will act as a conduit for exchanging information between representatives and recommending policy to the Strategy Board. Each nation will be encouraged and funded to hold a national FuturICT Day to bring together the FuturICT research community in that country and to exhibit the work of the project to businesspeople, policy-makers and members of the public. As well as national integration, FuturICT will support scientific hubs - communities of researchers who specialise in particular topic, such as data mining, serious games or agent modelling. These hubs will include researchers from several countries, and will be incentivised in include representatives from recently-joined member states.

The need for economic growth and development will be balanced with the provision of social good by making the resources open to public scrutiny at all stages, and by putting the good of society at the heart of what FuturICT will achieve. The distribution of Focus Areas and Workpackages has been balanced to institutions and countries across Europe, and across disciplines.FuturICT will balance the needs of established and new researchers by providing funds and opportunities for short-term and long-term projects and exchange visits. Under-represented groups will be encouraged to participate through targeted initiatives.

3.3 Management plan

3.3.1 Professionalism through use of an experienced, qualified Project Office

The **Project Office** will provide professional support to the scientists who will be managing and carrying out the FuturICT programme of work. The staff members will be based at either or both ETHZ and UCL, and as far as possible will have experience of managing EU projects in addition to their professional qualifications. Project office members will be encouraged to visit their colleageus at the sister institution, and to make occasional visits to partner sites in order to become familiar with local practices and constraints.

3.3.2 Risk mitigation

The principal risks facing FuturICT are (i) funding shortfall, (ii) temporary or permanent unavailability of key personnel, and (iii) ethical or functional inadequacy, including failure to deliver key outputs of the project.

Funding shortfall
The FuturICT funding stream will be sourced from the EU, national agencies, and commercial and private donations. Professional financial management by the Project Office will ensure that the amount of funding available will be carefully monitored and reported to the Strategy Board and Management Committee. FuturICT's funding stream will come from various sources, i.e. EU funding, national funding agencies, universities' in-kind contributions, commercial sponsorship, benevolent donations, royalties and licence earnings,which will help to provide robustness. Should funding from the EU not meet expectations, the next round of planning at Horizon2020 will be adjusted to raise a greater proportion of the funds from other sources, such as national agencies, and private donors. The Resources Manager of the Project Office will seek out and support the management and development of new funding sources. Implementation plans for the reallocation of funds, with impact assessments, will be carried out by the Executive Board. Adjustments up to an agreed limit can be carried out by the Executive Board without escalation to the Strategy Board. Changes above that threshold will have to be escalated to the Strategy Board for their discussion and approval.

Unavailability of key personnel
During a project of 10 years duration, some of the key personnel will surely be offered alternative employment, or become indisposed. Each of the committees will have a nominated deputy and a succession plan. Each of the workpackages will be led by a team of scientists, with nominated deputies. The Project Office will maintain and hold a central archive of committee papers so that responsibilities may be handed over should a key person be indisposed or required for other responsibilities. Each workpackage will be encouraged to have regular team meetings by Skype or face-to-face, so that the teams share a high level of awareness of the WP's goals, objectives and deliverables, and the state of progress.

Ethical or functional inadequacy, including failure to deliver
Progress against scheduled deliverables will be reported for each work package at least once every six months, and likely quarterly during the FP7 phase. If progress is inadequate, the work package leaders may explain the obstacles to their progress to date, and propose a recovery plan to the Executive Board. If this is not accepted, the Executive Board may propose its own action plan, which may then be escalated to the Strategy Board if the financial implications exceed the limits available to the Executive Board. Where there is an ethical issue, this will be presented to the Ethics Committee and the Strategy Board, for possible review of the FuturICT ethics policy and recommended response to the ethical issue. Where a Focus Area of Workpackage PI is not able to bring their area of responsibility under control, they will be invited to suggest a replacement who will be able to improve the performance of the Focus Area or Workpackage. The Executive Board will oversee the process of replacement, and may offer other nominees. The Strategy Board will contain representation from significant partner organizations and the

Coucil of Partners will also have visibility of poorly performing Workpackages or Focus Areas, thereby providing advice and assistance should a Workpackage or Focus Area get into difficulties.

3.3.3 Procedures for internal review

The progress on the work packages will be monitored and reviewed by the Executive Board, but the reviews of the procedures and strategy of the FuturICT Project will be carried out every three years by a **Strategic Review Team** (SRT), proposed by the FuturICT Ambassadors. There will be around five members of the SRT, combining scientific and managerial expertise from universities, research centres, potential and actual FuturICT users, national funding agencies and commercial organizations around the world. The SRT will have access to all documents relating to the management of the FuturICT project, including financial, contractual, commercial and scientific reports. They will be able to interview colleagues at all levels of the project, and will be expected to visit research centres and Observatories associated with the FuturICT project. Funding will be made available to support their travel and as an honorarium for their time. Their report will be presented to the FuturICT Strategy Board, where the recommendations of the report will be reviewed and enacted as appropriate.

3.4 Expertise of individuals and quality of core consortium as a whole

There will be 12 Focus Areas of FuturICT, nine of which will conduct research, and three that will provide management, coordination, workshops and outreach. Each of the nine research Focus Areas will be led by a team of scientists who will combine social science, ICT and complexity science, as far as possible. Two scientists will be the PI and deputy for each Focus Area, and they will be responsible for managing their Focus Area's deliverables. They will be expected to attend meetings of the Executive Board and the Science Board. Typically, these leaders may also lead a WorkPackage within that Focus Area.

The scientific Workpackage leaders are drawn from across Europe: UK, Italy, Switzerland, Germany, Hungary, Netherlands, Austria, Isreal, Belgium and France. Many of the workpackage leaders already have experience of leading significantly large research projects, while some have limited experience, but will be provided with support and training by the Project Office as well as their home institution. While we have included many top scientists with high h-indices, we are aware of the shortcomings of these metrics, and have balanced the team with young scientists and those from disciplines with citing behaviours that are not well-represented by the h-index.

The governance of the project will support openness, teamwork and transparency of leadership, with scientific leadership and teamwork at the heart of the FuturICT project. FuturICT is thoroughly interdisciplinary, with multi-disciplinary leadership teams for Focus Areas, and throughout the governance structure. Together, we have the scientific calibre, the governance processes and the commitment, as indicated in the letters of support.

Chair of Strategy Board: Prof. Dirk Helbing was the initiator of FuturICT and has chaired the Steering Committee of the pilot project, and will become Chair of the Strategy Board. He has a broad academic background, having studied physics and mathematics, and was Managing Director of the Institute for transport & Economics at TU Dresden. He is now Professor of Sociology at ETH Zurich, and is elected member of the prestigious German Academy of Sciences "Leopoldina". His research includes agent-based modelling of techo-socio-economic systems and their computer simulation; lab and web experiments; and the mining of social activity data, the socio-inspired design of ICT systems, disasters, and systemic risks. He has 200 peer-reviewed publications in different scientific fields, and has appeared frequently in the media. He has worked with various companies, including Xerox PARC, Volkswagen, SCA Packaging, Siemens and PTV. He established the ETH Competence Center "Coping with Crises in Complex Socio-Economic Systems" and the "Risk Center", which develop computer models of crisis

scenarios and provide decision support on politics and the economy.

Focus Area 1: PNS - Towards a Planetary Nervous System
Focus Area and WP Leaders: Paul Łukowicz, Fosca Gianotti, John Shawe-Taylor, Dirk Helbing, Andrzej Nowak
Prof Paul Łukowicz, FA1 co-leader, FA1 WP1 is Professor of Embedded Intelligence at DFKI (Germany). His research is devoted to adaptive, intelligent systems seamlessly integrated in the environment, including wearable computing, sensors and sensor networks, activity and context recognition, software tools, system models, and a wide range of pervasive computing applications. His team is particularly interested in large scale systems that self organize to cooperate in dynamic, opportunistic configurations, with an emphasis on health and wellness related systems.
Prof Gianotti, FA1 co-leader, FA1 WP2 is Laboratory Head at ISTI, CNR in Italy. Her research includes data mining query languages, knowledge discovery support environment, web-mining, spatio-temporal reasoning, spatio-temporal data mining, and privacy preserving data mining. She has been the coordinator of both European and national research projects and she is currently the co-ordinator of the FP6-IST project GeoPKDD: Geographic Privacy-aware Knowledge Discovery and Delivery.
Prof John Shawe-Taylor, FA1 leadership team, FA1 WP3 is Professor of Computer Science at UCL. He has 200 research papers with over 20,000 citations and an H-index of 44. He has pioneered the well-founded approaches to machine learning inspired by statistical learning theory such as Support Vector Machines including varied applications.
Prof Dirk Helbing, Chair of SB, FA1 leadership team See bio at SB above
Prof Andrzej Nowak, FA1 leadership team is Director of the Center for Complex Systems at University of Warsaw, Poland, and holds faculty positions at University of Warsaw, the Professional School of Social Psychology in Warsaw, and is permanent half-time member of the Psychology Department of Florida atlantic University. His research is on the modelling and computer simulation of social processes. Current research projects include the use of cellular automata to simulate the emergence and maintenance of self-concept and linear and non-linear scenarios of societal change, the use of attractor neural networks to model interpersonal and group dynamics, and the use of coupled dynamical systems to simulate the emergence of personality through social coordination.

Focus Area 2: LES - Towards a Living Earth Simulator
Focus Area and WP Leaders: Petros Koumoutsakos, Min Chen, Dino Pedreschi, Donald Kossmann, Andreas Flache, Maxi San Miguel.
Prof Petros Koumoutsakos, FA2 co-leader, FA2 WP1 holds the Chair of Computational Science at ETH Zurich. His interdisciplinary background includes a PhD in Aeronautics and Applied Mathematics (CalTech) and post-doctoral studies in High Performance Computing (CalTech and Stanford), Masters degrees in Aeronautics (CalTech), Naval Architecture (UoM) and Naval Architecture and Mechanical Engineering (National Technical University of Athens). He is a world expert in multi-scale modelling and simulation and High Performance Computing, and conducts research at the interfaces of Engineering, Nanotechnology and the Life Sciences.
Prof Min Chen, FA2 co-leader, FA2 WP2 is Professor of Scientific Visualisation at the Oxford eReseach Centre, University of Oxford. His research interests include visualization and computer graphics; video processing and visualization; and interactive techniques and multimedia communications. He has ran the Computer Science department at the University of Swansea from 2009 to 2011. He has published over 135 research papers and received over č11M research funding.
Prof Dino Pedreschi, FA2 co-leader, FA2 WP3 is Professor of Computer Science at the University of Pisa, Knowledge Discovery and Delivery Laboratory (Italy). His research interests are data mining and logic in databases; spatio-temporal reasoning; and formal methods for deductive computing. He has experience of large international and EU projects, having been the coordinator of the international working

group on non-determinism in deductive databases, jointly sponsored by the European Union and the US National Science Foundation.

Prof Dr Donald Kossmann, FA2 WP4 is Professor for Computer Science at ETH Zurich. He has held positions at the University of Maryland, the IBM Almaden Research Center, the University of Passau, the Technical University of Munich, and the University of Heidelberg. He is co-founder of the companies i-TV-T (1998), XQRL Inc. (acquired by BEA in 2002), and 28msec Inc. (2007). His research interests lie in the area of databases, information systems, and cloud computing.

Prof Andreas Flache, FA2 leadership team is Professor of Sociology at the Department of Sociology of the University of Groningen and board member of the research school ICS (Interuniversity Center for Social Science Theory and Methodology). His research is on co-operation and social integration and how these are related to the structure and emergence of social networks. He has published in American Journal of Sociology, Journal of Conflict Resolution, Rationality and Society, Journal of Mathematical Sociology, and Proceedings of the National Academy of Sciences.

Prof Maxi San Miguel is Professor of Physics at the University of the Balearic Islands (since 1986) and Director of Institute for Cross-Disciplinary Physics and Complex Systems, CSIC-UIB, Palma de Mallorca. He has published over 315 articles in refereed journals and books, and has been cited over 7,200 times. He was awarded the Medal of the Spanish Physical Society-Fundación BBVA 2010. His research interests include stochastic processes and fluctuations in non-equilibrium systems, collective dynamics in social systems and complex networks.

Focus Area 3: GPP - Towards a Global Participatory Platform

FA and WP Leaders: Simon Buckingham Shum, Sara de Freitas, Albrecht Schmidt, Vittorio Loreto, Markus Gross, van den Hoven, Loreto.

Dr Simon Buckingham Shum, FA3 co-leader, FA3 WP1 is Senior Lecturer and Associate Director of the Knowledge Media Institute, Open Univesity (UK). His research is in technologies for sensemaking, and which structure discourse to assist reflection and analysis, such as D3E, Compendium, ClaiMaker and Cohere. He has championed and supervised 15 projects involving innovative approaches to learning within the context of social media, narrative hypermedia and the semantic web.

Prof Sara de Freitas, FA3 co-leader, FA3 WP4 is Director of Research and Professor of Virtual Environments at the Serious Games Institute, Coventry University. Sara has published extensively and has given international presentations and keynote lectures. She is the Scientific Coordinator of the EU Network of Excellence in Serious Games and currently holds 23 research projects, including 11 EU projects. Appointed Fellow of the Royal Society of Arts, Sara was voted the Most Influential Woman in Technology 2009/2010.

Prof Albrecht Schmidt, FA3 co-leader, FA3 WP2 is a Professor for Pervasive Computing and User Interface Engineering at the University of Duisburg-Essen in Germany. Previously he was head of department at the Fraunhofer institute for intelligent information and analysis systems. His teaching and research interests are in media informatics and ubiquitous computing, and in particular in the area of user interface engineering.

Prof Vittorio Loreto, FA3 WP3 is Professor of Physics at Sapienza University in Rome and research leader at ISI Foundation where he heads the Information Dynamics group. His scientific activity is on the statistical physics of complex systems and also granular media, complexity and information theory, network theory, and social dynamics. He is presently coordinating the EU project EveryAware that integrates environmental monitoring, awareness enhancement and behavioural change by creating a new technological platform combining sensing technologies, networking applications and data-processing tools.

Prof Jeroen van den Hoven, FA3 leadership team, FA9 WP1 is professor of Moral Philosophy at Delft University of Technology Netherlands) and is Vice Dean of the Faculty of Technology, Policy and Management. He is Scientific Director of the Centre for Ethics and Technology of the Three Technical Universities in The Netherlands and Editor in Chief of Ethics and Information Technology. He has published widely on ethics and ICT and has received several grants from the Dutch Research Council on Ethics and

Information Technology and related subjects. He has been advisor to the Dutch Government in various roles, including on the re-design of the population registration system and a commission that evaluated wiretapping.

Prof Markus Gross, FA3 leadership team is Director of Disney Research Zurich, and before that was Head of the Institute of Computational Science, ETH Zurich. He has pursued basic and applied research in the fields of computer graphics, image generation, geometric modelling, computer animation, and scientific visualization for more than 20 years. His technical achievements includes point-based computer graphics, virtual reality systems, 3D video, and physically based animation.

Focus Area 4: Socio-Inspired ICT and Principles of System Design

FA and WP Leaders: Fausto Giunchiglia, Frank Schweitzer, Márk Jelasity, Alois Ferscha, Eve Mitleton-Kelly

Prof Fausto Giunchiglia, FA4 co-leader, FA4 WP3 is professor of Computer Science at the University of Trento (Italy). His research has been in many areas including Artificial Intelligence, Formal Methods, Software Engineering, automated reasoning, theorem proving, model checking, planning, contexts and contextual reasoning (and logics for modelling it), reasoning about propositional attitudes, and agents and agent oriented software engineering. He has been involved in the development of software systems, such as GETFOL, and an implementation of (now Open Source) NuSMV. He has extensive adminsitrative experience as Head of the Deaprtment of ICT and three years as Vice-Rector of University of Trento.

Prof Frank Schweitzer, FA4 co-leader is Professor of Systems Design at ETH Zurich, and an associated member of the Department of Physics. The recent focus of his research group is on applications of complex systems theory to the dynamics of social and economic organizations, including the development of formal concepts, quantitative modelling and computer simulations. He is Editor-in-Chief of *European Physical Journal B: Condensed Matter and Complex Systems*, with responsibility for the section Complex Systems, and is Editor-in-Chief of *Advances in Complex Systems* and is a member of the editorial board of several economics and physics journals.

Dr Márk Jelasity, FA4 WP1 is Senior Research Scientist at the Research Group on Artificial Intelligence of the Hungarian Academy of Sciences, University of Szeged (Hungary). He is working on the QLectives project which combines social networks, peer production and peer-to-peer systems. He has also worked on the BISON EU-funded project on self-organization in dynamic networks, so has experience of socially-inspired ICT within EU-funded projects.

Prof Alois Ferscha, FA4 WP2 is Professor at the Johannes Kepler University (JKU), Linz, and head of the department for Pervasive Computing. His current research focuses on Pervasive Computing, Embedded Software Systems, Wireless Communication, Multiuser Cooperation, Distributed Interaction and Distributed Interactive Simulation. He has been the project leader of several national and international research projects, and he has built application frameworks for, amongst others, the JKU "Wireless Campus" network; geo-enhanced, augmented reality mobile navigation systems ("SmartRoad"); RFID-based real-time notification systems; and wearable computing and embedded internet application frameworks ("DitgitalAura", "SmartCase", "DigiScope").

Prof Eve Mitleton-Kelly, FA4 leadership team is Senior Research Fellow in the Insitute of Social Psychology, LSE. Her speciality is relationship between policy and outcomes; corporate governance and project governance,agent-based modelling, complexity theory, socio-technical change and cultural frameworks, and the creation of enabling environments based on complexity science. She has acted as policy advisor to European and USA organizations, the European Commission ans several UK Government Departments.

Focus Area 5: IA - Towards an Innovation Accelerator

Fa and WP Leaders: Frank van Harmelen, Katy B¨orner, Stuart Anderson, Jeff Johnson, Santo Fortunato, Dirk Helbing

Prof Frank van Harmelen, FA5 co-leader, FA5 WP2 is professor of Knowledge Representation and

Reasoning at the VU University Amsterdam, where he leads one of leading groups on Semantic Web reearch. Microsoft Academic lists him as one of the 100 most cited Computer Science authors in the past decade. He co-authored the first Semantic Web textbook. He was one of the co-designers of the W3C standard Web Ontology Language OWL. He was scientific director of the LarKC project that developed the Large Knowledge Collider, a platform for very large-scale semantic web reasonsing.

Prof Katy Börner, FA5 co-leader holds several appointments in Information Science and Complex Systems in Europe and the US. She Research Affiliate of the Center for Complex Networks and Systems Research and Biocomplexity Institute, Member of the Advanced Visualization Laboratory, Leader of the Information Visualization Lab, and Founding Director of the Cyberinfrastructure for Network Science Center at Indiana University in Bloomington, IN. She became an American Association for the Advancement of Science (AAAS) Fellow in 2012.

Prof Stuart Anderson, FA5 leadership team, FA5 WP1 is professor of Dependable Systems and Deputy Head of the School of Informatics at The University of Edinburgh. He works within the Social Informatics Cluster at Edinburgh that brings together researchers in Informatics, Sociology, Geography, Economics, organizational Science and Medicine to study the social embedding of ICT in complex organizations. His research is in the area of safety, trust and the dependability of socio-technical systems. He was Edinburgh PI on the Dependability IRC which was the main UK research initiative in the area and one of the largest EPSRC projects, in this area.

Prof Jeff Johnson, FA5 leadership team, FA5 WP3 is Professor of Complexity Science and Design at the Open University (UK). He is Head of the Department of Design, Development, Environment and Materials, and is President of the Complex Systems Society. He is lead partner in the EU projects ETOILE (Enhanced Technologies for Open Intelligent Learning Environments) and ASSYST (Action for the Science of complex SYstems for Socially intelligent icT). He has many years of experience of coordinating multi-partner EU projects in complexity and complex systems.

Prof Santo Fortunato is Associate Professor in Complex Systems, Department of Biomedical Engineering and Computational Science (BECS), Aalto University, Espoo, Finland. His research publications are on complex networks, social dynamics, percolation theory and statistical field theory. He is Associate Editor of Advances in Complex Systems, and a member of the Editorial Board of PLoS One and EPJ Data Science. He acts as referee for many publications including Science, Nature and Nature Communications.

Prof Dirk Helbing, FA5 leadership team See bio above at Strategy Board.

Focus Area 6: Theoretical Foundations of a Global Systems Science

FA and WP Leaders: László Barabási, Dirk helbing, Shlomo Havlin, Vincent Blondel, Nigel Gilbert, Vittoria Colizza

Prof Albert-László Barabási, FA co-leaders, FA6 WP2 has carried out distinguished and seminal research in complex networks, that has been widely published in the popular media and the scientific press. He has worked with large data sets and is experienced at running large, multi-disciplinary research projects. He holds a number of appointments, and is a Distinguished University Professor at Northeastern University, where he directs the Center for Complex Network Research.Barabási published several books that have been translated in as many as 11 languages. His work on complex networks has been widely featured in the media, including the covers of Nature, Science News and many other journals.

Prof Dirk Helbing, FA6 co-leader See bio above.

Prof Nigel Gilbert, FA6 leadership team, FA6 WP1 is professor of sociology at the University of Surrey (UK), where his research and teaching combine his interests in sociology and computer science. Specifically, his research is in Computational social science, sociology of science and science policy, innovation, consumer behaviour, sociology of the environment, privacy and surveillance. He is editor of the Journal of Artificial Societies and Social Simulation, and Social Research Update. He is also involved in the EU-funded projects QLectives, SIMIAN (Simulation Innovation: a Node) and ERIE (Evolution and Resilience of Industrial Ecosystems).

Prof. Shlomo Havlin, FA6 WP3 is a Professor of Physics at Bar-Ilan University. He is a leading expert

and pioneer in many aspects of complex systems, and in particular he developed recently a mathematical framework to study interdependent networks (Nature 2010). He also applied network theory in various fields including economy, social systems and climate. He won many prizes including the recent Lilienfeld APS Prize, USA (2010), and the Weizmann Prize for Exact Sciences, Israel (2009). Prof. Havlin authored more than 650 articles published in prestigious scientific journals like Nature, PNAS and PRL, and 11 books.

Prof Vincent Blondel, FA6 leadership team, FA6 WP4 is professor of Applied Mathematics in the Department of Mathematical Engineering at Université Catholique de Louvain (Belgium). His research is on complex networks and dynamical systems, the analysis of mobile phone networks, community detection and algorithmic complexity in systems and control. He has been a visiting professor at MIT and runs a research group on large graphs and networks. He has been involved in a number of EU projects including Hycon, Euler and Dynamo.

Dr Vittoria Colizza is Senior Research Scientist at the INSERM, UnitMixte de Recherche en Santè 707, and Université Pierre et Marie Curie, Facultè de Mèdecine, in Paris, France. I also have a joint appointment at ISI Foundation in Turin, Italy, where she leads the Computational Epidemiology Lab. Her research focuses on the characterization and modelling of the spread of emerging infectious diseases, by integrating methods of complex systems with statistical physics approaches, computational sciences, and geographic information systems.

Focus Area 7: Interfaces, Standards and Systems Integration

FA and WP Leaders Thomas Bohnert, Ann Blandford, Phillipp Slussalek, Donald Kossmann, Alex Vespignani

Dr Thomas Bohnert, FA 7 co-leader, FA7 WP1 is currently with the Zurich University of Applied Scineces, having worked previously at the SAP Research Labs in Zurich as technical director and chief Future Inernet Strategist. He founded an ICT consultancy and ran it for four years. His interests include future internet business models; cloud computing; service, solution and technology strategy for telecommunication and software industries. Dr Bohnert brings experience of internet research and technical business start-ups.

Prof Ann Blandford, FA7 co-leader is Professor of Human-Computer Interaction at UCL (UK), where she has been director of UCL's interaction Centre, a joint initiative bentweem the Division of psychology and the Department of Computer Science. Her research interests are on evaluating complex systems "in the wild", whether in relation to human error or the use of information within the working context. She has published extensively on many aspects human comptetr interaction and understanding.

Prof Dr-Ing Phillipp Slussalek, FA7 leadership team is Professor of Computer Graphics at Saarland University (Germany), and is Scientific Director at the German Research Center for Artificial Intelligence (DFKI), leading the research lab Agents and Simulated Reality. He is also Director of Research at the Intel Visual Computing Institute and Principal Investigator at the Cluster of Excellence in Multimodal Computing and Interaction, which is in close collaboration with the Max Planck Institute for Informatics the Max Planck Institute for Software Systems. Prof Slussalek has managed large research projects and been Dean of the Faculty of Mathematics and Computer Science. He has international experience having been Visiting Assistant Professor at Standford University.

Prof Donald Kossmann, FA7 leadership team See bio under FA2.

Prof Alex Vespignani, FA7 leadership team, FA8, WP2 See bio under FA8.

Focus Area 8: Towards Exploratories of Society, Economy, Technology and Envirnoment

FA and WP Leaders: Alex Vespignani, Didier Sornette, Rosaria Conte, Jamie MacIntosh, Mike Batty, Marco Ajmone-Marsan, Guillaumee Deffuant

Prof Alex Vespignani, FA8 co-leader, FA8 WP2 is a professor at NorthEastern University and has worked in a number of areas of non-equilibrium particle systems, statistical physics and computational

sciences, most recently in the interdisciplinary application of statistical and numerical simulation methods for the analysis of epidemic and spreading phenomena and the study of biological, social and technological networks. He is now focusing his research activity on modelling the spatial spread of epidemics, including the realistic and data-driven computational modelling of emerging infectious diseases, the resilience of complex networks and the behaviour of techno-social systems. Prof Vespignani has extensive experience of running large multi-site, multi-disciplinary research projects in Europe and the US.

Prof Didier Sornette, FA8 co-leader, FA8 WP1 is chair of Entrepreneurial Risks at ETH Zurich (Switzerland) in the Department of Management, Technology and Economics. He is Director of the Financial Crisis Observatory and co-founder of the Competence Center for Coping with Crises in Socio-Economic Systems. He has experience of industry having been Director of Research in X-RS, an R&D company in Orsay, France. He was scientific advisor to the Technical Director of Thomson-Marconi Sonar (now THALES). He has published very extensively and has supervised many graduate students and post-doctoral researchers. His research priorities concern modelling the behaviour of financial markets during bubbles, and on predicting crises and extreme events in complex systems.

Dott. ssa. Rosaria Conte, FA8 leadership team, FA8 WP3 is Research Director and Member of Scientific Committee of the CNR, and is head of the LABSS (Laboratory of Agent Based Social Simulation) at the ISTC (Institute for Cognitive Science and Technology). She is a cognitive and social scientist, with a special interest for the study of positive social action (altruism, cooperation and social norms), and reputation-based social regulation. She is coordinator of European and Italian research projects.She is Former President of the European Society of Social Simulation and has helped to establish the field of social simulation in Europe. Her research interests range from Agent Theory to Multi-Agent Systems, from Agent-Based Social Simulation and Cultural Evolution to Info-Societies and Virtual Markets.

Dr Jamie MacIntosh, FA8 WP4 is Director of the Institute for Security & Resilience Studies (ISRS) and an Honorary Professor at UCL. After a decade's service in the British Army he became a government research scientist in 1995. He led teams that pioneered the use of complexity science in strategy, policymaking and decision support. In June 2001 he co-authored the concept of Resilience to Crises (R2C), which was endorsed by the UK's then Prime Minister. He has advised cabinet ministers at home and abroad in pragmatic ways to promote resilience, which relies on the healthy uptake of innovation - particularly during crises.

Prof Mike Batty, FA8 leadership team, FA8 WP5 is Bartlett Professor of Planning at UCL where he is Chair of the Centre for Advanced Spatial Analysis (CASA). His most recent books are Cities and Complexity (MIT Press, 2007) for which he received the Alonso Prize of the Regional Science Association in 2011, Virtual Geographic Environments (edited with Hui Lin, ESRI Press, 2011), Agent-Based Models of Geographical Systems (edited with A Heppenstall et al., Springer 2012). He is editor of the journal Environment and Planning B. He was elected a Fellow of the British Academy in 2001 and the Royal Society in 2009, and awarded a CBE in the Queen's Birthday Honours in 2004 for 'services to geography'.

Prof Marco Ajmone Marsan, FA8 WP6 is a Full Professor at the Electronics and Telecommunications Department of Politecnico di Torino, in Italy, and a part-time Chief Researcher at IMDEA Networks in Madrid, Spain. He has held several senior appointments, including Director of the Institute for Electronics, Information and Telecommunications Engineering of the National Research Council of Italy; and Vice-Rector for Research, Innovation and Technology Transfer of Politecnico di Torino. He is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), and he is Listed in Thomson - ISI as a highly cited researcher in Computer Science (ISIHighlyCited.com).

Prof Guillaume Deffuant, FA8 WP6 is the scientific leader of the "Laboratoire d'Ingénierie des Systèmes Complexes" in Irstea, and co-director of the French National Network for Complex Systems. He has been involved in several European projects applying agent-based models in environmental issues and recently coordinated a FET project about resilience and viability. He is the author and co-author of frequently cited papers about opinion dynamics.

Prof Albrecht Schmidt, FA8 leadership team See bio at FA3.

Focus Area 9: Towards Ethical and Value-Sensitive ICT
FA and WP Leaders: Jeroen van den Hoven, Eve Mitleton-Kelly, Stefan Bechtold, Dino Pedreschi, Alois Ferscha.
Prof Jeroen van den Hoven, FA9 co-leader, FA9 WP1 is professor of Moral Philosophy at Delft University of Technology (Netherlands) and is Vice Dean of the Faculty of Technology, Policy and Management. He is Scientific Director of the Centre for Ethics and Technology of the Three Technical Universities in The Netherlands and Editor in Chief of Ethics and Information Technology. He has published widely on ethics and ICT and has received several grants from the Dutch Research Council on Ethics and Information Technology and related subjects. He has been advisor to the Dutch Government in various roles, including on the re-design of the population registration system and a commission that evaluated wiretapping.
Prof Eve Mitleton-Kelly, FA9 co-leader See bio at FA4.
Prof Stefan Bechtold, FA9 leadership team is Associate Professor of Intellectual Property at ETH Zurich. His research interests include intellectual property, law and technology, telecommunications law, antitrust law, as well as law and economics. He has taught and studies at Stanford, Bonn, Munich and Amsterdam.
Prof Dino Pedreschi, FA9 leadership team See bio at FA2.
Prof Alois Ferscha, FA9 leadership team See bio at FA4.

Focus Area 10: Project Management, Coordination and Flagship Framework
FA and Leaders: Steven Bishop, Agatha Keller, Janet Smart, Thomas Bohnert, JB McCarthy
Prof Steven Bishop, Chair Executive Board, FA10 WP1 has been Coordinator of the Pilot Phase of the FuturICT project. He has been serving as Chair of the Management Committee. Prof Bishop will continue to chair the Executive Board. Steve is Professor of Mathematics at University College London (UCL), with a broad range of research interests in the area of non-linear dynamical systems. He is currently involved in a major, multidisciplinary, five-year EPSRC-funded project exploring four interlinked social systems and developing appropriate policy responses.

Prof Bishop will work alongside Martin Scott who will lead the Project Office. **Martin Scott** will lead the Project Office. He is the Senior European Project Manager, University College London, where he leads University College London's European Project Management service, a team of five staff specialising in the financial, administrative and contractual management of EU Framework Programme projects. The team is responsible for 21 currently-running FP7 projects with a combined budget of over Ă98 million. Martin is a registered PRINCE2 practitioner and holds a postgraduate diploma in International Project Management, with a specialist focus on Project Cycle Management and European collaborative project management.
Agatha Keller, FA10 co-leader is head of the Research Grants Office at ETH Zurich, and has many years experience of managing large multinational science projects, especially under FP7.
Dr Janet Smart, FA10 co-leadership team, FA10 WP2 is Senior Research Fellow at the Saïd Business School, University of Oxford, where she has been teaching and researching the management of major projects and programmes, with particular interest in the management of big science projects such as ATLAS and CERN. She has been developing the governance model for FuturICT. Otherwise, her research has been on the complexity of manufacturing systems and supply chains.
Prof Thomas Bohnert, FA10 co-leadership team See bio at FP7.
JB McCarthy, FA10 co-leadership team See bio at FP11.

Focus Area 11: Dissemination and Workshops
WP Leader: JB McCarthy
FA11 WP1: JB McCarthy is Development Director for the Financial Services Innovation Centre (FSIC) located in University College Cork (UCC), Ireland. JB has an MBA from Northeastern University, a BSc in Computer Science from UCC and a Diploma in MIS from the Irish Management Institute. Focused on building relationships and engaging in innovative research and development projects with industry partners,

JB is an accomplished IT industry executive with several years experience in North American Corporate HQ environments as well as managing complex projects across several disciplines and geographies (EMEA, Asia and South America). JB has published several conference and journal papers related to the service industries.

3.4.1 Quality of the core project consortium as a whole

The FuturICT consortium has brought together a community of about 1000 scientists, registered on our website. We have over 170 letters of support from academic institutions, universities, government agencies and notable individuals. We have shaped a leadership team that combines skills across the three contributing sciences, while combining scientific and organizational leadership and experience. We have put in place a governance structure, and appointed members who are already helping to form policy and make operational decisions. Focus Area and Workpackage leaders will be supported by the Project Office, and will be provided training and support to enable them to deliver to the milestones on schedule. The Executive Board will meet regularly so that PIs are aware of the progress of the constituent parts of the project, and can be responsible for the success of the project as a whole.

The Focus Area coordinators are spread across the three principal scientific disciplines, and most have experience in running large research projects, either within their own university or as part of a multi-national collaborations. Many have experience of working in countries other than their own country of birth or education, and many have worked in North America or outside Europe. We have included people with demonstrated experience and competence in managing complex projects and delivering outcomes and researchers with prolific publication records. Many FA leaders have already set up businesses, so will be able to contribute to the successful exploitation of FuturICT research outcomes. There will be opportunities for young researchers to move up through the research and committee structures as the FuturICT project matures, and the original consortium members may move on to other roles.

The Workpackages have been defined with a mixture of quite tightly focussed projects, and other that will require interdisciplinary and inter-organizational collaboration. Project funding will be available, either through FuturICT or support from national sources, to enable visits and exchanges so that meaningful collaboration can be encouraged and implemented. Prizes for inter-disciplinary projects, papers and outcomes will be awared during FuturICT Week. The FuturICT Weeks will be held in different nations each time, encouraging visitors and longer research stays. Particular emphasis will be placed on enabling young researchers to visit and collaborate on research and exploitation, making links with local SMEs and business incubator communities.

Not only are European scientists themselves enthusiastic about breaking down the barriers between research diciplines, their Universities agree too. Universities across Europe have provided letters of support indicating that they will be creating new posts aligned with FuturICT's research agenda. Furthermore, at the highest levels, the need for multi-disciplinary research has been recognised:

> "[In] the face of crisis, we felt abandoned by conventional tools. ... The key lesson ... is the danger of relying on a single tool, methodology or paradigm. The atomistic, optimising agents underlying exiting models do not capture behavior during a crisis period. Agent-based modelling ... allows for more complex interactions between agents. ... we need to better integrate the crucial role played by the financial system into our macroscopic models." "I would very much welcome inspiration from other disciplines: physics, engineering, psychology, biology. Bringing experts from these fields together with economists and central bankers is potentially very ... valuable."

Speech of Jean-Claude Trichet, Former President of the European Central Bank, on November 18, 2010.

3.5 Approach to flexibility of the partnership

3.5.1 Outline of proposed legal structures

Two successive EU Grant Agreements will be entered into between the European Commission and a core FuturICT consortium of beneficiary institutions, forming the contractual backbone of FuturICT's legal structure. There will also be an ERA-NET Plus agreement, entered into by the national funding agencies that will be participating in the FuturICT project.

The first of these agreements will govern the implementation of the 'ramp-up' phase of the project via the FP7 instrument 'Combination of Collaborative Project and Coordination & Support Action'. The second of these agreements will relate to the 'full Flagship' phase of the project, to be implemented under the upcoming Horizon 2020 programme.

The beneficiary institutions will deliver the project in line with the agreed-upon tasks, deliverables and budgets within these Grant Agreements, and will contribute their own resources to the project in line with the normal Rules for Participation relating to European projects, in this case an ERA-NET Plus.

The beneficiary institutions entering into the two FuturICT Grant Agreements will also enter into a comprehensive Consortium Agreement that will govern, amongst other things:

- The implementation of the project and procedures for decision-making and dispute resolution;
- The ownership, management and exploitation of the project's Intellectual Property;
- The project's financial provisions and rules for the distribution and accounting of project resources;
- Standard procedures and regulations governing relationships between FuturICT beneficiary institutions and third parties;
- Confidentiality obligations and dissemination protocols.

The beneficiary institutions will retain the freedom to enter into specific agreements with 'third party' organizations during the ramp-up and full Flagship phases. These agreements will allow organizations who are not direct beneficiaries of the EU Grant Agreements to participate in the FuturICT initiative. Such participation will be possible through the provision of various resources, including staff time, and through access to FuturICT's platforms, data, networks and events.

Agreed direct costs incurred by the third party organizations will be fully reimbursed by the project, via the beneficiary institutions, and this open and inclusive arrangement will allow participation in the project by a large number of organizations who are not yet members of the core consortium. A clear and transparent pathway towards participation will also be set in place and publicised, allowing the project to remain as open as possible to third party participation as it develops.

FuturICT's key 'Coordinating Hubs' (UCL, ETH Zurich, and others still to be formally agreed) have already entered into negotiations to establish a jointly-owned legal entity under the auspices of the project. This entity will take the form of a 'European Economic Interest Grouping' (EEIG), and its creation will act as a major step to ensuring the permanence and long-term viability of the FuturICT initiative.

3.5.2 Calls for FuturICT proposals

The FuturICT project will maintain flexibility and responsiveness to new technologies and evolving research priorities throughout the lifetime of the project. This will require skilful management to maintain the project vision while adapting to the concurrent evolution in technologies and research outcomes, and maintaining the support and commitment of the various stakeholder groups, such as the funding agencies, business and commercial collaborators and the community of scientists. In order to achieve this, the Strategy Board will from time to time issue calls for proposals. The subject and broad parameters of the

call will be set by the Strategy Board, and the details of the acceptance criteria, timeline and selection of reviewers will be decided and agreed by the Executive Board. The management of the actual processes of publicising the call, receiving proposals, sending proposals for review, receiving reviews, calling the selection panel, issuing decision notices and negotiating contracts will be managed by the Project Office. The reviewers and members of the selection panel will be agreed between the Strategy Board and the Calls advisory Board. Grants may be awarded to organizations who were not original partners through Third Party agreements.

text Vision and flexibility over extended duration of project
In order to build the project vision throughout the early ramp-up phase, and into the Horizon 2020 phase and beyond, FuturICT's vision is being communicated to the broad community of scientists, funders, businesspeople and EU citizens through its website and a very active social media campaign. The FuturICT vision has been clarified through the Pilot phase, which has developed the shared vision within the community. The process of developing and communicating the vision will continue throughout the project, alongside the community-building work. Apart from the ongoing outreach by the Project Office, the wider FuturICT community will be kept abreast of developments through the publicity events and conferences that will take place during the FuturICT Weeks. As well as a program of conferences, public presentations and exhibitions, funding will be made available for students, artists, members of the public, businesspeople etc to set up new strands of discussion, exhibition and displays. Competitions, training workshops, multi-media showcases will contribute to the building of community, communication of FuturICT project outcomes, and discussing, developing and sharing the FuturICT vision.

3.5.3 Links to other networks

The governance structure of FuturICT provides a number of mechanisms for supporting links to other networks, as well as forming and supporting networks within FuturICT. So far, we have identified 175 other projects that are related to FuturICT, and are confident that we will be able to form effective workin glinks with a focussed number of these (See Appendix 3). In particular, the structures for managing the work packages are built on the assumption that the scientists will be working in semi-formal networks, built on the social and professional relationships already in place. The principal mechanisms for linking to other networks are the ERA-NET Plus, the special interest groups and the national hubs. The special interest groups will be based on particular topics, such as data mining, visualization etc., and will identify and integrate groups across Europe and beyond, whether directly funded by FuturICT or not, who are interested in particular specialist topics. These groups may be associated with more than one scientific workpackage, Observatory etc. They may apply to FuturICT for funding to arrange conferences, workshops and exhibitions etc. The national hubs will form a repository and integration of the work that is going on in each nation or local region so that the FuturICT community in each country is aware of each other's work and may also be able to organize annual get-togethers to share outcomes, findings and progress, and to seek to develop opportunities for further sharing of ideas and development of collaborations. Many of the scientific leaders of FuturICT are already integrated into a number of other networks, which will invited to send members to FuturICT Weeks, and the meetings indicated above.

3.6 Allocation of resources to be committed

The Strategy Board will be responsible for recommendations on the strategy and policy of balancing sources of funds, through their decisions on how to balance income from public funds, private donations, technology transfer (i.e. licensing, spin-outs and exploitation).

The Management Board will be responsible for the practical implementation of such recommendations.

Section 4

Impact

4.1 Transformational impact on science and technology

Promoting European scientific leadership and technological competitiveness After the age of physical, biological and technological innovations, FuturICT will lead Europe into the next era - a wave of Big Data-driven social and socio-inspired innovations. The vision of the FuturICT flagship project is to develop the capacity to explore and manage our future, based on a fundamental understanding of the institutional and interaction-based principles that make connected systems work well. Many of the scientists who will be working on this project already have experience of working in more than one discipline, so have a rich and deep scientific understanding, combined with the ability to communicate with colleagues from different disciplines. This ability to break down the barriers facing multi-disciplinary research is a great strength of FuturICT and European researchers, enabling us to move forwards quickly on a complex project. This strength will equip the FuturICT team to quickly marshal the human and financial resources to achieve powerful breakthroughs during the first 30 months of the project, under the FP7 phase.

Strengthening interfaces between ICT, complexity science and social science The FuturICT flagship project is founded on the integration of natural, social, and engineering sciences with novel paradigms of information technology. The research topics and governance structures of ICT will support the exchange of ideas and technologies between disciplines through shared research projects, exchange visits, multi-disciplinary conference and workshops, and promoting shared publications and research outputs. FuturICT has already demonstrated effectively how collaborations may be put in place betwen disciplines, and we will continue to support these links, since the goals of FuturICT cannot be achieved without effective, equitable interdisciplinary collaboration.

4.1.1 Key technological breakthroughs expected

We list below the key scientific breakthroughs that are expected from the FuturICT project.
FA1: Planetary Nervous System will gather data to present a picture of the state of our world, integrating heterogeneous data. This will improve our ability to manage a complex and heavily-populated world, achieving improved sustainability, and providing the resources for Observatories of financail instabilities, social challenges, health and epidemics etc.
FA2: Living Earth Simulator will develop scalable, multi-agent simulation platforms, enabling the exploration of what-if scenarios and the implications of decisions and policy interventions; identifying the hitherto unanticipated side-effects and comsequences of decisions and natural events, such as planning decisions on major infrastructure projects (e.g. future cities), evacuation scenarios, the spread of epidemics etc. Modelling tools will be designed and developed for use by non-experts.

FA3: The Global Participatory Platform will create a new type of data commodity, that will enable bottom-up participation in social, economic and political affairs, leading to more bottom-up inolvement in decision-making at all levels of deomcracy. This will facilitate personalised education and customized services; create non-expert systems (accessible to everyone without prior training); empower citizen science; and develop principles for open platofrms that promote responsible and ethical use.
FA4: Socio-Inspired ICT and Principles of Systems Design will develop collective awareness in society, improving and extending social adaptiveness and socio-inspired self-organization. Principles of of cooperation, self-regulation, conflict resolution, resilience, trust, social norms, values, ethics and culture will be embedded in the ICT systems, making systems easier for users to understand and accept.
FA5: Innovation Accelerator will build an integrated, learning crowd wisdom system, that can learn to identify new trends, inventions and innovations; learn how to measure science and innovation in a multi-criteria way; enable personalized education; develop new IPR approach and principles for differential, collective innovation (including suitable incentive schemes); facilitate crowd funding; and lead to the creation of an integrated communication, coordination, and collaboration platform.
FA6: Global Systems Science will develop a better understanding of strongly coupled, complex, global techno-socio-economic systems, made up of components with internal complexity and cognitive ability, that involve communication, forecasting, prediction and estimation. This would have breakthrough consequences for the modelling of social policies.
FA7: Interfaces, Standards and Systems Integration will consider the breadth and depth of the technical standards for the FuturICT project, enabling standards to be agreed between the PNS, LES, GPP, Exploratories and Observatories. This will enable the FuturICT consortium to continue to grow as new technologies can be included and new tools and sensors can be added to the FuturICT infrastructure.
FA8: Exploratories and Observatories The main breakthrough will be the integration of PNS, LES, and GPP functionality (i.e. data mining, computer simulation, and interactivity/participation) and application to practical challenges in order come up with exemplar case studies. The Observatories will implement massive data mining and suitable filtering techniques to detect forth-coming or possible crises, e.g. bubbles or crashes in financial or housing markets ("market monitoring"); identify advance warning signs for financial and economic instabilities, for shortages in supply (e.g. energy, water, food), wars and social unrests, epidemics, environmental change, etc.; extract laws of systemic instabilities; identify interdependencies, feedback loops, and causality chains that may lead to cascade spreading effects. This will require new economic models which track instabilities and cascading effects with spatial outcomes down to the city level, particularly in terms of housing markets, and migration. Generating economic data and predictions which are spatial and local is a main priority, linking various themes across workpackages in this Focus Area involving financial systems, health and epidemics, social challenges, crime, and energy systems.
FA9: Ethical and Value-sensitive ICT will be at the centre of FuturICT, investigating what needs to be taken into account at the technical level to allow the PNS to become a public commodity, and creating value for the citizens of Europe. The Focus Area will identify the dangers and potential of Big Data, develop privacy-respecting data mining; learn and demonstrate how to promote the responsible use of open platforms; understand the downsides of innovation; and create a culture of ethical awareness and respect.

4.1.2 Breakthroughs expected in scientific collaboration

As aready mentioned, FuturICT will continue to promote multi-disciplinary scientific collaboration, and this will be enhanced further by the Innovation Accelerator, which will enable scientists to communicate more effectively and will support a novel, rapid, flexible approach to publication, delivering the outputs of FuturICT to scientists, policy-makers, businesspeople and citizens more quickly and effectively than ever before. Combined with the Global Participatory Platform, this will be a breakthrough in enabling people

to have access to information and models, providing scientists all over Europe and the world with new means to share and test ideas, and to quickly build their own versions and conduct experiments. This will lead to a much-needed and long overdue paradigm shift in the dissemination of scientific and other ideas, integrating work from the arts, sciences and engineering.

4.2 Transformational Impact on economy and society

Today, the impact on the European and global economies of poorly understood health, tranportation, economic and corruption systems are resulting in the loss of trillions of dollars and huge damage to health and well-being.

- **Epidemics:** Disruptions associated with SARS led to an immediate economic loss of about 2% of East Asian regional GDP (US$20 billion) in the second quarter of 2003 (WHO). A true influenza pandemic infecting just 0.5-1% of the world population (up to 65 million people) would probably see economic losses run to 1 to 2 trillion dollars per annum over a period of perhaps 2-3 years, based on current GDP data (Oxford Economic Forecasting Group, 2005).
- **Traffic congestion:** In the UK alone, eliminating existing congestion on the road network would be worth some £7-8 billion of GDP per annum. Every day 7,500 kilometres of European highways areblocked by traffic jams. Congestion on roads and at airports adds 6% to the EU's fuel bill with a corresponding rise in pollution levels.
- **Financial crises** An estimate of crisis-related bank writedowns between 2007 and 2010 is $2.2 trillion (IMF).
- **Corruption]** Several rough estimates of the cost of corruption range from 2 to 5 percent of global GDP, which amounts to $800 billion to $2 trillion in current U.S. dollars.
- **Military expenditure:** Global military expenditure stands at over $1.5 trillion in annual expenditure at current prices for 2009. This represents a 6 per cent increase in real terms since 2008 and a 49 per cent increase since 2000 (Stockholm International Peace Research Institute). Just a 10% reduction would save $150 billion per year.

If FuturICT were able to acheive just a small percentage improvement, the impact on European economy and society would be vast and far-reaching.

The **economic** impact of FuturICT will include:

- **New businesses and new business models** The European economy is looking for new routes to growth and employment. The components of FuturICT, particularly PNS, LES and GPP, will lead to the development of nimble new businesses and start-ups that will use new mobile technologies, sensors and devices to create new services and deploy them rapidly and efficiently. Delivering a Data Commons, Model Commons and and an OPen Brokerage Service could lead to innovations in business and services, whether public or commercial. These could lead to improvements in the efficiency of public services, energy consumption, local awareness and community building. FuturICT technologies and approaches can play a foundational role in building new service enabled business models that transcend all industry and government verticals. By tapping into the data and combining that with the best models we will deliver optimised services for the benefit of the end consumer, which could be businesses or citizens. The knowledge and services economies can be further stimulated by FuturICT services to deliver innovative commercial offerings that have pan-European possibilities and can be further extended as a global service offering.

- **Better understanding of financial systems** As Trichet pointed out, poor understanding of the financial system led to the crash of 2007, causing trillions of dollars of losses, and damage that is still being felt in the global economy. The global economy needs better models of the econo-social systems, that are affected by many scales of time and agent behaviour, so that we may seek to avoid or diminish the impact of such damaging economic situations in the future, through better, more informed mining of real-time data to detect emerging or possible crises or crashes in financial markets, supply shortages, and social unrest.

The **social** impact of FuturICT will also be extensive:

- **Social challenges** The challenges of dealing with corruption, crime, conflict, and war (including civil war) cost billions in the judicial processes, as well as the social and personal consequences on individuals, communities and nations. A better understanding of the processes that lead to these situations could lead to new designs for cities and communities; improved policies and policy interventions; better abilities to detect the onset of conflicts and find solutions that avoid the loss and damage caused by crime, corruption and conflict. Internet networks may also be used to enable crime, cyber-crime and terrorism, and the detection and analysis of these networks may also help to avoid their growth and impact.

- **Improved health** The Observatory on Health and Epidemics will improve the ability to predict the outbreak and spread of diseases. Simulations of medical policy interventions, such as selective vaccination or closing down transportation netowrks, can be simulated to select the most appropriate method to curb the spread of epidemics, whether in response to a crisis (such as influenza) or as part of a long-term social policy, such as adjsuting social policy to reduce obesity, smoking and depression.

- **Better democratic institutions** By presenting the complex information on which policies are chosen by government, citizens can challenge the assumptions on which the models are based, and gain a better understanding of how the policies would affect their own lives. This will enable people to make better, more informed decisions about policies, whether at the local or national level. This could lead to an improvement in democratic participation and better understanding by all stakeholders in the possible or likely consequences of particualr decisions and actions.

These benefits will be achieved by involving industrial and commercial collaborators, including SMEs, in the work of FuturICT through a number of means. Businesspeople will be involved in the management and development of FuturICT through their participation in the Users' Representative Group, that advises the Strategy Board, involving regular consultation on the research outcomes and directions of FuturICT. There will be at least one business representative on the FuturICT Strategy Board. The Technology Transfer Board will present the research outcomes as business opportunities to their panels of investors and business contacts. FuturICT Weeks will showcase FuturICT research and development ideas to business, including SMEs. Focus Area leaders with experience of setting up their own businesses or consulting with companies and policy-makers will be encouraged to suggest new contacts and advise on the presentation of ideas and development of business plans. Small companies will be encouraged to work with young researchers who are interested in bringing new business ideas rapidly to market.

The economic impacts on society of pandemics, traffic congestion, financial crises, global warming, corruption and the drug trade, war and crime alone, are huge. If FuturICT were to make even 1% improvement in the economic impacts in Europe alone, it would pay for itself many times over.

FuturICT has put in place a transparent, open, flexible and ethical governance procedure in order to ensure that the research directions and outcomes are available to all; are open to scrutiny; are based on ethical principles and reviews; and will lead to the maximum possible social and economic benefits.

The global scale of the issues being addressed means that policy-making, while often subject to national concerns, is inevitably international, both through the policy-making processes of the EU and through

global institutions such as the United Nations Framework Convention on Climate Change and the WHO. The EU plays a critical role, both in terms of intra-EU policy development and in terms of international policy processes. Worldwide, every year, governments spend billions on promoting innovation.

FuturICT will generate important datasets, simulations, scenarios and decision-support tools for the policy-making community of the European Commission and National Governments. For example, simulations should help policy makers to (i) understand the dynamics of funded innovation networks (e.g., what are the key components of a successful innovation network?), (ii) diagnose problems in existing networks (e.g., is there something missing in European biotechnology innovation networks?) and (iii) predict the outcomes of policy decisions (e.g., if the EU increases support for researcher mobility between industry and academia, what impact will result?). There is a great sensitivity in many cultures regarding possible wide reaching government control ('Big Brother'), which can only be countered by demonstrating openness and transparency from the start and clearly focus on the democratising nature of better understanding the very processes driving our societies. Therefore, FuturICT will enhance Europe's knowledge economy and competitiveness internationally and advance innovation in its public and private sectors. The development and distribution of the world's resources will need innovative approaches to policy development and implementation, which will be enabled by FuturICT's development of a set of radical, paradigm-changing results that will provide novel methods of modelling and prediction. FuturICT will provide tools allow humanity to cope better with the major challenges of today and tomorrow. The complexity in our ICT systems and the techno-socio-economic challenges of humanity in the 21st century require our society to make a large-scale federated investment to counteract disastrous cascading effects, negative interferences, and tragedies of the commons, and fill the current knowledge gaps to enable this. The FET Flagship Call by the European Commission provides a unique and timely opportunity for this.

4.3 Alignment with regional, national, European and international research programmes, and sustainability of foreseen support

The interdisciplinary research required to fully exploit Big Data is extremely new, and current efforts are fragmented across disciplines, communities and countries. A core goal of the FuturICT project is to encourage and integrate these distributed research efforts to ensure maximum value is generated from the financial and human resources dedicated to this endeavour, and to build up new capacity across Europe to continue this research effort into the future. Substantial progress has already been made in this task through the efforts of the project team to visit and liaise with local and regional researchers and funding agencies.

Regional and national research programmes

The FuturICT project has found widespread support for its proposed activities, from within the university and business sectors and from the national funding agencies and bodies. Many universities have pledged to support the FuturICT project throughout its lifetime, giving a reliable funding stream for the years ahead, sufficient to add over €70m in cash and inkind to the funding stream during FP7. This funding includes som long term commitments, such as new graduate courses at La Sapienza and POlitecnico di Torino, and new faculty posts at TU Munich and trinity College Dublin. These are serious commitments, demonstrating long-term alignment with the goals and vision of FuturICT.

National funding agencies can only commit within their planning horizon, so their contributions will be reviewed during the FP7 phase of the project, with the view to renewing their commitment after a successful ramp-up phase. Given the long-term commitment indicated below, we are confident that FuturICT has a sustainable future.

In the *UK*, the University of Edinburgh has committed €5m per year on ICT related to the Innovation Acceperator and a further €5m per year on FuturICT-related research. The Open University has committed €1m per year in the Knowledge Media Institute, and €0.5m per year in the Institute of Educational

technology. The UK's EPSRC and ESRC have expressed interest in supporting FuturICT, but are unwilling to commit until the EU have announced a funding decision. However, FuturICT-related have received č138M support through the multi-disciplinary Digital Economy programme, in three research hubs and seven doctoral training centres, providing many opportunites for collaboration and coordination of research activities. The EPSRC envisages that contributions to FuturICT could operate on many levels, from financial support of FuturICT, to ongoing steering guidance to ensure that Flagship activities and efforts towards the EPSRC's future strategic goals are aligned.

In *Switzerland*, ETH Zurich has committed CHF 100m over the years to the FuturICT project, including in kind faculty posts, and support for the ETH Risk Centre. Up to CHF 80m will be available for supercomputing hardware. Reserved time will be provided on the HP2C platform. The Risk Center at ETH Zurich is supported by significant donations from industry and Integrated Risk Management is now one of the key pillars of ETH Zurich's strategic research.

Italy's La Sapienza University will provide €5m per year to support researchers, €0.3m to support a new Masters programme with 30 students and a further €200k per year to provide a new interdisciplinary research centre. The Politecnico de Torino has committed €2.5m per year to support researchers and €0.5m to support the PhD programme. Italy's IMT (Institutions Market Technologies) has committed €2m per year as staff, facilities and equipment. CNR (Consiglio Nazionale delle Ricerche IIT currently plans to provide €1m per year for each of the first two years. Altran Italia have commited 15 FTE staff, corresponding to €700k for the first two to three years of the project. Several action areas of the FuturICT are aligned with the research policies of the National Program of the *Italian* Ministry of Research (Programma Nazionale Ricerca, PNR), such as Security, Environment, Energy and ICT for Future, which will provide €1m per year for the first two years.

University College Dublin will provide over the lifetime of the project €3m to support appointments, €400k to create a new Applied Research Centre for the Social Sciences, €6m for new facilities for the CASL and Clarity, as well as hosting a number of national postgraduate programmes relevant to FuturICT. Trinity College Dublin, *Ireland* will provide access to their High Performance Computing Centre.

The Hungarian Ministry of National Resources plans to €24m in grants over the next three yeras, including 3.7m for a higher education and FuturICT research centre. The Central European University of Budapest, *Hungary* has committed to provide €500k in 2013, increasing as the FuturICT project matures. This will include two new professorships.

Tel-Aviv University in *Israel* has pledged €300k per year, as has the University of Haifa.

The University of Amsterdam has pledged €2m per year from 2013. The University of Gronigen will provide the same amount, with €1m per year from 2013, and a further €1m through the faculties of Sciences, Social Sciences, Economics and Business. Four themes of the *Netherlands* organization for Scientific Research (NWO) for the period 2011-2014 dovetail naturally with FuturICT. These are Water and Climate, Cultural and Societal Dynamics, Sustainable Energy and Connecting Sustainable Cities. Results from ongoing projects from the current NWO theme Dynamics of Complex Systems will also be beneficial to FuturICT.

The *French* Complex Systems Roadmap 2008-2009, involving scientists from all the main French research institutes, aims to identify a set of wide thematic domains for complex systems research over the next five years. This is well-aligned with the objectives of FuturICT, e.g. how interactions between individual agents lead to social cognition, and the "mystery of innovation" and its diffusion. The PEER network of French institutes for research on the environment would also support a long-term research program focusing on large simulations of land or water use, and is represented on the FuturICT team by Prof Guillaume Deffuant.

The *Spanish* Science department plans strong progress in a number of areas aligned with FuturICT, including Energy and Climate Change, and Telecommunications and Information Society. The Barcelona Supercomputing Centre will provide a research team and facilities.

Within the *Portuguese* Foundation for Science and Technology (FCT), several scientific domains sup-

porting public policies are in strong alignment with the goals of FuturICT. These include Environment and Global Changes; Health Sciences Epidemiology; Public Health and Environment, Economics and Business; Social Sciences - Sociology, Demography, Studies on Science and Society; and Political, Education and Information Sciences.

The *Polish* Ministry of Science and Higher Education has guaranteed to provide financial support to cover the expected costs for the Polish teams involved in FuturICT. The *Slovenian* Ministry of Higher Education has also committed to provide €4m in grants, which will be combined with the €6m provided by individual organizations, giving a total of €10m. The Johannes Kepler University in *Austria* will provide a supercomputer.

European research programmes
Within the Commission, FuturICT demonstrator areas are clearly in line with many other research programmes, such as energy, sustainability, health, and governance. Whilst the project could not be carried out within one of these programmes alone, FuturICT will be able to coordinate activities across these disciplines, allowing it to leverage funds accordingly.

FuturICT's plans align perfectly with the European Strategy Forum on Research Infrastructures (ESFRI)'s efforts towards the scientific integration of Europe through common policy-making on research infrastructures. A range of European projects and initiatives are already working in close collaboration with FuturICT. These include the Climate-KIC, EIT ICT Labs KIC, and the PEER, FOC and VISIONEER projects, to name a few. Existing projects currently running or planned to run concurrently with FuturICT are listed in Appendix 3.

International research programmes
FuturICT has succeeded in attracting the support of top scientists on an international level. As part of the Flagship, we have already established collaborations with Sandy Pentland's world leading lab within the Media Lab at MIT. We will build on connections to Smart City initiatives in Singapore. Support from Japan and Australia is also strong.

Sustainability of foreseen support
The pledged support from University partners is very strong and is committed for the lifetime of the project, including new posts and postgraduate degree programmes in FuturICT-related subjects. We will continue to review our profile of support during the ramp-up phase, and will raise further funding from business as well as national agencies and new FuturICT team members.

4.4 Use of results and dissemination of knowledge

Exploitation and Technology Transfer of FuturICT IP
FuturICT's Project Office will have access to the Technology Transfer Offices (TTOs) of, principally, UCL and ETH, although it will interact with the TTOs of all partner universities. As the project moves into Horizon2020, a Technology Scout will be engaged to review and assess the potential for exploitation of FuturICT IP, whether through business start-ups, technology licenses or patents. The PO will include legally-qualified professionals who will be able to advise on the preparation of contracts to protect and manage the FuturICT Intellectual Property.

The FuturICT Strategy Board will be advised by a Users' Representative Panel that will include representatives of SMEs as well as larger corporations. Many of the researchers who will be involved with or leading WPs already have experience of setting up or working in business, so they will be encouraged to seek out new business ideas, as well as advising and possibly mentoring younger or less experienced colleagues who are interested in exploiting the outcomes of the FuturICT research.

4.4.1 Dissemination

FuturICT will continue to employ a range of media to disseminate its work, including research plans and projects; personnel and events. Of course, FuturICT employ the Innovation Accelerator in addition to the familiar dissemination routes.

Academic publications
FuturICT will use the normal academic publications routes of books and book series; new journals; journal articles; conferences; workshops and other events. FuturICT Weeks will arrange a number of events each year, including events and demonstrations for businessepople, journalists, policy-makers and members of the public. these events will be hands-on and interactive, and will be supported by training in the Public Understanding of Science in order to ensure a high quality experience for the citizen-taxpayers. Where possible, all publications will be available through open access.

Webpage, social media, television, the arts and printed media
FuturICT has its own logo and brand (see front cover) and has set up a website that has received 72,507 pageviews from 1 October 2011 to 30 April 2012, representing 26,674 visits by 14,741 unique visitors. FuturICT has very active communities of followers on LinkedIn, Twitter and Facebook. These have delivered a high level of awareness of the work of FuturICT during the period between October 2011 and April 2012, bringing 476 "likes" on Facebook, FuturICT has 600 followers on Twitter, producing over 500 tweets, FuturICT has 185 LinkedIn members during the same period. During the time period between January and April 212 the FuturICT blog has had over 500 pageviews. We will continue to devote resources specifically to this activity, as an effective means of promoting awareness of FuturICT's work to our stakeholder communities of interest.

FuturICT will continue to engage with the printed media, through press releases and articles in newpapers and magazines. Profs Helbing, Bishop and Barabasi are particularly experienced in giving presentations and interviews to journalists, and we will continue to provide media training to colleagues who would like to expand this skill. Short, filmed interveiws of the principal scientists engaged in FuturICT are available on our webpage, and through Vimeo and YouTube, and we will continue to encourage colleagues to prepare their own short films for dissemination through the website.

We will continue to build links with arts organizations (see letters of support), who will provide new ways of presenting, visualising and stimulating the creative work of the FuturICT project. FuturICT collaborated with Ralph Dum, from DG INFSO, to organize an Art & Science Connect event, which was held in Brussels 26/27 April, to bring together groups who have already had successes in this area and nucleate new concepts for future actions. The event was stimulated and introduced by Robert Madelin, Director General of INFSO, and included an exhibition of artists' work. We will continue to include arts events, firstly to support dissemination of the outputs of the FuturICT project, but also to continue to leverage collaboration between scientists and artists as a path towards different creative viewpoints on the FuturICT vision. We will continue to use professional firms to help us develop the FuturICT brand so as to ensure clear ownership of our results and attribution to the funders.

Dissemination to particular stakeholder groups, such as experts, practitioners, policy-makers, businesspeople and the media, will be encouraged through the activities of the national and regional FuturICT hubs. This will continute to be facilitated through the provision of local language presenters and interview experts with supporting documentation on a non-profit basis at a variety of events and towards a variety of target groups; extensive support materials on the FuturICT website. Reports of meetings of the principal committees of FuturICT will also be reported on the website.

4.5 Education and training at European level

Education is widely considered to be a major force for the economic and social well- being of the citizens of Europe and the World. Through education we aspire to tech- nological progress to improve the lives of everyone and to achieve social justice, understanding and international peace. Education makes individuals and societies better adapted to thrive in a changing world. Despite these aspirations, millions of people have no access to education at any stage in their lives. Even in Europe many of our citizens are provided with an inade- quate education, leaving many young people with poor knowledge and skills and poor prospects for work and a satisfying independent life. Education has a crucial role to play in the context of the FuturICT Knowledge Ac- celerator. On the one hand many individuals must be educated to have the basic knowledge and study skills to participate in the FuturICT adventure. On the other hand, FuturICT aims to provide new knowledge and understanding of social and technical systems. This opens up completely new methods to accelerate the processes of teaching and learning.

We identify five Grand Challenges in Education:

1. Enable orders of magnitude more people to learn more effectively than they do today.
2. Provide interdisciplinary education that combines depth of knowledge in some disci-plines and breadth of knowledge across the disciplines.
3. Devise new methods of creating education to respond to accelerated acquisition of knowledge and deliver that education to people throughout their lives.
4. Provide highly effective interdisciplinary and specialist education to large numbers of people throughout their lives at low cost.
5. Provide interdisciplinary education across the traditional scientific domains to create a large cadre of people trained in complex systems science, systemic risk, integrated risk management, integrative systems design and realistic modelling of techno-socio- economic systems.

FuturICT is ideally placed to contribute to a revolution in the means of delivering education, moving away from the traditional approaches of chalk-and-talk lectures, textbooks and printed materials, and moving towards searchable texts, movies, and animations, supported by Peer-to-Peer learning models where students collaborate and use social media to encourage and improve each other's learning. During the life of FuturICT we can expect a revolution in our knowledge about the ways human being learn things, and how ICT can enable a much better understanding of the structure of knowledge and how networks of knowledge evolve.

Personalised learning and teaching
FuturICT will combine information on a student's past and present state to design and deliver teaching materials better suited to a student's actual, present needs. New ICT platforms will enable large depersonalised databases of individual and collective learning trajectories, which, when combined with collaborative filtering methods and extended recommender systems, will provide powerful new ways to extend the educational choices open to individuals at all stages in their lives. FuturICT will provide infrastructure and knowledge that will empower individuals to learn, and it will support them not just as individuals but also as members of self-supporting educational and scientific communities.

Virtual Classroom, Virtual Lecture Theatre and Virtual Laboratory
One reason for conventional education being expensive but ineffective is that it is conducted in geographically distributed purpose-built spaces with specialised equipment, based on an educational model devised in the early days of the first universities. Since 1969 the Open University in the UK has demonstrated that well-made teaching materials can support self-study as effectively as face-to-face lectures. ICT and the internet have greatly increased the possibilities for self-study in virtual spaces and social structures.

The potential of this is greatly enhanced when combined with ICT supported social structures such as social networking enabled by the FuturICT platforms.

Social Networking and Peer to Peer Teaching and Learning
One of the best ways to learn is to teach others. Social networking promises a great deal for P2P education. In principle social networking can transcend geography, culture, and social level. A poor, young person in one country may give instruction to a rich, older person in another country, and vice-versa. A problem with P2P education that needs to be overcome is the possibility of students giving each other incorrect guidance, promoting incorrect views and spreading misunderstanding.

Peer Assessment
Peer assessment can address some of the five educational Grand Challenges. It has been shown to be effective in engaging students in the development of their own learning, and in developing understanding of different thinking styles.

Links and collaborations within FuturICT
FuturICT will be developing robust practices for ensuring the security and privacy of personal data, and will be researching new ethical practices for handling and utilising large amounts of personal data. New data storage technologies will form a significant part of FuturICT's deliverables. These technologies will be crucial to the effective development and delivery of the Education Accelerator agenda. The Global Participation Platform (GPP) will develop new tools to explain concepts and present data to a wide range of stakeholders, using techniques such as data visualisation, immersive environments and serious games. Many of these will be developed co-operation with experts in education, so the goals of both components of the FuturICT vision will be aligned, and will cooperate through exchanges of personnel, workshops, joint publications and events.

The International Digital Campus
A number of universities in Europe and the US are using the Internet to create a Digital Campus, making use of the new methods of peer-to-peer teaching, learning and assessment. It will enable everyone to benefit from ubiquitous low-cost learning, which will be fast and pleansant to use, giving everyone the route towards available anywhere, always on, personalised learning and education.

FuturICT's five Grand Challenges in Education The Education Accelerator will re-examine conventional motivations for learning and the things that demotivate learners. New motivations will be devised including: ICT-enabled methods of establishing reputation within social groups and competition to join desirable social groups; and motivating social technologies such as computer games. The Education Accelerator will be delivered as an international virtual campus exploiting the new knowledge of social organization generated by FuturICT in the context of new ICT science and technology

Graduate student and postdoctoral exchange and training
FuturICT is committed to building capacity in interdisciplinary science by creating new career paths for young scientists. The FuturICT Coordination Action proejct has already started a Young FuturICT movement to connect young researchers from many of the groups that interact with the project. La Sapienza University and politecni di Torino, amongst others, are setting up new postgraduate courses in FuturICT-aligned topics, and TU Munich and University College Dublin are investing by creating new posts. In order to build up capacity in FuturICT's combination of sciences, a virtual course will be set up linking research institutions across Europe. A PhD programmes is already under development under the ERASMUS MUNDUS scheme for Joint Master Courses / Joint Doctorate Programmes in "Technological and Social Complex Systems". Prof. Robert MacKay (University of Warwick) is responsible for this project. Students and eligible post-docs will be encouraged to attend short courses to introduce them to the theory and methods at graduate level of scientific disciplines that they might not have encountered in their previous training. The courses will combine virtual laboratories and virtual classrooms, with opportunities to meet as a group in a key location. Peer-to-peer training and assessment will also be

developed and tested with this group. Funding for course development and travel will be included with support for FuturICT graduate students.

Capacity at European level will be developed through setting up new interdisciplinary positions at universities across Europe. These posts will support course development and teaching at undergraduate and postgraduate levels, and will create a career path for aspiring academic teachers and researchers. Funding for these posts has already been committed by a number of universities.

4.6 Potential ethical and legal implications

Ethical implications

FuturICT has a strong ethical motivation. In particular, the project is determined to promote the development of responsive, responsible and ethical ICT. Under FuturICT, decision-making will be enhanced by access to an unprecedented range of data and tools to make sense of them, and decision-makers will be given the ability to forecast and explore multiple scenarios. This will lead to decision-making in society being more informed, which in turn will improve individual and collective well-being. The long-term goal is to have an inclusive approach, making these capabilities available to all interested individuals. Whilst the goals in themselves may be well-intentioned and ethical, any technology that collects information about humans implies risks for privacy. Without privacy-respecting and secure, ethical processes and procedures, collecting data from all devices, services, and data related to a given user, and following their behaviours, attitudes, and social interactions would enable total surveillance. In the wrong hands, it can lead to social sorting, where some citizens and consumers are not offered certain options and services, and are not even aware that they exist. Effective legal and technical mechanisms need to be identified to prevent discrimination and exclusion.

Over a 10-year time period, FuturICT wants to provide an open data, simulation, exploration and participatory platform for everyone. This is is intended to establish a new public good on which all kinds of services can be built, i.e. it will support both commercial and non-profit activities. To prevent misuse of the platform and enable reliable high-quality services, it will be built on principles of transparency, accountability, reputation, and self-regulation. FuturICT is not interested in tracking individual behaviour or gathering data on individual actions. Its aim is to understand the macroscopic and statistical interdependencies within the highly complex systems on which we all depend. The FuturICT project will have a strong research focus on ethical issues, and is committed to informing the public about the use of socio-economic data. FuturICT will promote the development of privacy-respecting data mining technologies that give users control over their data. It will strongly engage in preventing and counter-acting the misuse of data and the Internet. More broadly, the project will seek public involvement to build and sustain confidence in its values of trust, security, fairness, transparency and ethical behaviour.

Moreover, new policies and procedures to establish future standards and adequate protection of privacy within massive data mining activities shall be elaborated. To ensure the Flagship develops technologies that safeguard against invasions of privacy and manipulation, FuturICT will have an Ethics Board, which will oversee all data collection activities, and develop policies and training for collection and mining large-scale datasets in an ethical manner. The Ethics Board will commence its work with a review of state-of-the-art frameworks and mechanisms safeguarding security and privacy - particularly relevant are those developed by existing FET projects in PerAda, such as ATRACO. The proposed Flagship will therefore engage in research into ethics, emergent norms, codes, the development of new data-sharing technologies providing users the control over their data ('new deal on data') and the suitable governance of research and development.

Finally, we consider it as a moral obligation to push the research directions promoted by the FuturICT project forward as quickly as possible. Given the fragility of the financial and economic system, the risks that this may ultimately impact the stability of our society and promote crime, corruption, violence, riots,

and political extremism, or even endanger our democracies and our cultural heritage are not negligible. Quick scientific progress is needed in order to learn how to efficiently stop the on-going cascading effects and downward trends. It is of similar importance to ensure that social and socio-inspired innovations will benefit humanity and not end up in the hands of a few stakeholders, as partially happened in genetics (particularly food production).

Legal implications

One of the possible indicators of success after 10 years of FuturICT will be changes to the laws regarding data, ICT systems and privacy protection of some or all of the EU countries. These could arise in a number of ways. Emerging directly from FuturICT's generation and exploitation of new intellectual property, there may need to be new ways to obtain royalties for apps that are distributed over many devices and which have complex webs of ownership, due to the interlinking of many contributing technologies.

A new Global Systems Science, that can deliver a more accurate and complete analysis of interconnected multi-level networks (e.g. transportation networks) may have implications for the responsibilites for desgning, building and operating complex communication networks. If systems have not been amended, after a FuturICT analysis of their risk profile, then new legal responsibilities may have to be defined. And FuturICT too may have to be aware of the consequences of errors in their analysis, which might lead to loss of business or reputational damage for commercial organizations involved.

FuturICT's intended ability to simulate future scenarios will be of value to politicians, regualtors and and policy-makers, since FuturICT may be able to show that particualr courses of action could possibly lead to severe consequences with a higher than acceptable probability. This could lead to changes in regulation, and new regulatory regimes being established. Other possible outcomes could be better models for the balance and level of taxation and welfare benefits, healthcare policies and a nation's energy, water and food supply networks. For all these reasons, FuturICT will consult and engage with experts in ethics, law and politics through its Ethics Board and Users' Representative Panel.

Policy discussions

FuturICT has been developing these issues in conversation with policy-makers at the highest levels of government, in the EU and nationally. The following is a short list of some of our recent contacts:

- Neelie Kroes, Vice-president of the European Commission,
- Catherine Margaret Ashton, Baroness Ashton of Upholland, European Union's High Representative for Foreign Affairs and Security Policy;
- Maria da Graca Carvalho, MEP
- Philippe Lambrechts, MEP
- Robert Madelin, Director-General of Information Society and Media D-G
- Helga Nowotny, President of the European Research Council
- Sean Sherlock TD, Irish Minister of State, Department of Enterprise, Jobs & Innovation and Department of Education & Skills, with responsibility for Research and Innovation
- Francesco Profumo, Minister of Education, Italy
- Dieter Imboden, President of the Research Council of the Swiss National Science Foundation
- Mauro Dell'Ambrogio, Secretary of State for Education and Research, Switzerland
- Jürgen Burri, Deputy Director of Swiss Secretariat for Education and Research
- Rt Hon Lord Reid of Cardowan PhD, former UK Home Secretary, Defence Secretary, Health Secretary

- Lord Julian Hunt of Chesterton, former Executive Director of UK Meteorological Office
- Dean Professor Willem van Genugten, The Hague Institute for Global Justice
- Madeleine Albright, Chair of the Advisory Board of The Hague Institute for Global Justice.
- Vince Cable, UK Secretary of State for Business, Innovation and Skills

The long-term objectives of FuturICT will make significant differences to life in Europe, creating and providing a new European paradigm to meet and exploit the age of Big Data. The **outcomes** will include new models that will integrate heterogeneous data, including the most up to date knowledge from the natural, engineering and social sciences. The sciences of ICT, social and complex systems will be challenged by data and complexity of global proportions, but will be be integrated and extended to develop a new Data Science, that will bring data and models together. FuturICT will provide new methods for knowledge creation and dissemination, through new platforms for experiments and simulations, mioning heterogeneous datasets at different geographical, spatial and temporal scales. These will be accessible to all through new participatory platforms that will allow new forms of information sharing, collaboration and political participation. A new Global Systems Science will provide a new approach to designing and managing complex systems, offering an alternative way of looking at systems, providing an integrationist rather than the reductionist paradigm available to engineers and designers now. This will lead to a new calculus of risk, better able to model and aticipate the systemic problems that are only visible to us now in hindsight. The European ethos of a publicly available, democratically accountable, commonly owned resource will be demonstrated through the new platforms that will provide citizen access to data and models that will increase everyone's awareness of health risks, financial performance, and environmental improvements, amongst others, creting a new information ecosystem. A new socio-inspired ICT will offer new ways to manage data, maintain ICT system resilience and respond to the needs of users, enabling new trustable, adaptive paradigms for collaboration to develop science and business. Ethics and respect for privacy and security are at the heart of FuturICT, driving a culture of value-sensitivity, respect, responsibility, responsiveness and awareness. Data will be held managed securely, and data-mining will be respect privacy always. Together, these outcomes will create a socially responsive ICT, that will meet the needs of, and co-evolve with, society.

Appendices

Appendix 1 FuturICT Support Letters

Appendix 2 Funding and support committed in cash and in-kind to FuturICT

Appendix 3 Selection of recent and ongoing EU projects aligned with FuturICT

Multimedia material relating to the FuturICT project may be found at `http://www.futurict.eu/`

For an up to date **list of letters of support**, except those pledging financila support, `http://dl.dropbox.com/u/6002187/Support_summary_list_0105.pdf`

To see all the letters of support, **except** those pledging financial contributions, `http://dl.dropbox.com/u/6002187/Supports_NoMoney.pdf`.

To see a **summary list** of the letters of support that **pledge** financial support, `http://dl.dropbox.com/u/6002187/Financial_Support_List.pdf`.

To see **all the letters of support pledging** financial contributions, `http://dl.dropbox.com/u/6002187/Supports_WithMoney.pdf`.