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European forward-looking activities:

Building the future of 'Innovation Union' and ERA

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Building the future of 'Innovation Union' and ERA

Additional insights from the European seminar that took place in Brussels on 3 March 2011.

2011

Directorate-General for Research and Innovation
Socio-economic Sciences and Humanities

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Contents

Key messages

Through its Innovation Union Flagship Initiative and the publication of the Green Paper 'Towards a Common Strategic Framework for EU Research and Innovation funding', the European Commission is developing a new approach to respond to the Europe 2020 Strategy. A smart, sustainable and inclusive growth needs a more efficient use of public money dedicated to research and innovation.

For preparing the Common Strategic Framework for EU Research and Innovation (CSF) and its Impact Assessment, the Commission organized in Brussels, on 3 March 2011, an interactive seminar with more than sixty European forward look practitioners (foresight and forecast experts) and European stakeholders, mostly coming from the research community, industry and civil society organisations.

The objective of this seminar was to take stock of recent national and European forward-looking activities on science, technology and innovation in order to explore different avenues for the future CSF. From national and European experience, several conclusions can be drawn:

Firstly, a new model of open and collaborative innovation driven by users should be developed recognising the role of innovative 'ecosystems' encompassing both technological and non-technological aspects such as social, economic and cultural forces.

Secondly, technological developments and social demands could be translated in future cross-cutting research and innovation fields such as 'Human-Technology cooperation' (machines interpreting information, better knowledge of human brain, etc), 'Sustainable living spaces and infrastructures for the future', 'Environmentally friendly and individually tailored solutions', 'Renewing services and production by digital means', 'Manufacturing on demand' and 'Urban mining'.

Thirdly, while Europe has to increase cohesion and convergence on research and innovation among EU countries, in the newly global innovation networks it has also to intensify the contacts with world scientific leaders and emerging countries.

Lastly, European Union research and innovation should grapple with major global societal challenges like natural resource depletion, energy and climate change and urbanisation, whilst at the same time tackling EU concerns of ageing, productivity and social cohesion.

The nexus between hard sciences and soft sciences, between engineering and social aspects, between grand challenges and daily citizens' life are increasingly relevant. Future research and innovation should take these points into consideration.

Robert Burmanjer, EC – DG Research and Innovation

Clara de la Torre, EC – DG Research and Innovation

Tim Jones – 'Future Agenda' Programme

Introduction

The aim of this seminar was set out by Robert Burmanjer, Head of Unit for Social Sciences and Humanities ([1]). In his welcome address he noted that the seminar brought together experts, national authorities, industrial stakeholders and EU policymakers to consider what insights for the future of EU research and innovation policies might be obtained from European and national forward-looking activities (FLAs). The seminar was designed to support the impact assessment of the upcoming EU research and innovation policies and programmes.

Impact assessment is a prerequisite for the adoption of Commission initiatives. Accordingly, an assessment of the new EU research and innovation activities should be presented by the Commission at the end of 2011. Substantial relevant evidence will need to be produced, screened, processed and clearly presented for this purpose. This seminar is one input into that process. In a somewhat similar spirit, the Commission has recently published a Green Paper designed to launch a comprehensive and broadly based public consultation on the key issues for the EU research, development and innovation (RDI) funding programmes that should be included in the next multiannual financial framework (MFF); this consultation will give to researchers, business, government and civil society communities and citizens the chance to engage and contribute ([2]).

The meeting comprised two main sessions, the first on 'Societal challenges: trends and perspectives' and a second on 'Science, technology and innovation: national and European outlooks'. These sessions explored the following topics.

- What recent national forward-looking activities tell us about the future of science and technology.
- What EU forward-looking activities tell us about societal challenges that need to be addressed by EU research and innovation.

These proceedings are based in the main on the presentations made at the seminar and the discussions in working groups and plenary sessions. The material has been extended to include some other publicly available material where it clarifies or elaborates a point; where this has been done it is referenced. There is no attempt to make a comprehensive review of all literature on these topics, but simply to draw on other sources occasionally where it is helpful to the argument.

(1) Welcome and introduction at the seminar on 'European forward-looking activities: Insights for building the future of Innovation Union and ERA', Robert Burmanjer.

(2) European Commission Green Paper — From challenges to opportunities: Towards a common strategic framework for EU research and innovation funding, COM(2011) 48.

The introductory presentation of Clara de la Torre, Director for Research and Innovation ([3]) in the Research and Innovation DG gave focus to the seminar. The financial crisis has not yet been fully contained and its eventual consequences are still not clear, but it is evident that it will leave Europe in a world of increased competition in which the EU, although not perilously exposed, is certainly vulnerable. The Union will have to grapple with many issues of a global character (resource depletion, climate change, conflicts of land use, poverty, water management) whilst also tackling problems that while not unique to the Union are a special concern within its boundaries (ageing, employment, productivity and social cohesion). As recognised in the Europe 2020 strategy ([4]), enhanced capacity to innovate is the absolute need that will determine whether we can deliver solutions to the complex and entangled problems that the world and Europe will face. At the same time, the innovative solutions that are expected need to be safe, accepted by society and sustainable.

According to the latest 'Innovation Union' scoreboard, indicators of innovation in Japan and the United States continue to grow faster than in Europe while emerging economies like India and China are moving from competition based on imitation and low cost to competition based on new and innovative products and they are catching up rapidly; their young populations are well disposed to novelty — both as producers and consumers of innovations. It is in this context that, on 6 October 2010, the Commission presented its proposals for a flagship initiative to turn Europe into an 'Innovation Union' by 2020. This Union is predicated on an integrated and strategic approach where innovation policy is steered at the highest political level and in which innovation objectives shape policies in all relevant areas. Within the 'Innovation Union', framework conditions for RDI would be much improved, making Europe more attractive for RDI investors and entrepreneurs. Deficiencies identified in the present framework include ([5]):

- poor availability of finance;
- costly patenting;
- lack of legal and tax level playing field;
- outdated regulations and procedures;
- slow standard setting;
- weaknesses in public education and innovation systems;
- failure to use public procurement strategically;
- fragmentation of efforts.

Much needs to be done to correct these weaknesses in the framework conditions: the European research area should be completed by 2014; a Euro-

(3) 'Europe 2020 and Innovation Union: Setting the scene', Clara de la Torre.
(4) European Commission, 'Europe 2020: A strategy for smart, sustainable and inclusive growth', COM(2010) 2020.
(5) Presentation of José Manuel Barroso to the European Council, 4 February 2011.

pean patent introduced; standard setting simplified; public procurement used more widely and skilfully to promote innovative products and services; access to venture capital facilitated and a digital single market created. In a period of deficit reduction, it is critical to safeguard investments in areas on which future growth depends: RDI, education and skills, high-speed Internet and ICT infrastructure.

Maximising the efficiency of expenditures on RDI is clearly important, especially in times of financial stringency. The EU intends to lead by example and spend in a 'smart' way that enhances growth. Simplifying the administration of the framework programme is a top priority, but it is also necessary to simplify the relationships between instruments and to deploy them more skilfully. As part of this process, the Commission has developed the idea of European innovation partnerships that would pool expertise and resources to accelerate research, development and market deployment of innovations to address selected major challenges. The intent is to cover the whole RDI value chain, ensuring that the conditions are conducive to bringing the results of R & D successfully to market and that the numerous existing instruments at EU, national and regional levels are deployed effectively to a common purpose. The arrangement is to be piloted in a partnership to promote innovation for active and healthy ageing. Further partnerships are under preparation.

Forward-looking activities are crucial to successful policy in RDI as in much else. To establish priorities for research we must try to understand the future, to anticipate what might happen and to agree how best to manage events to achieve social and political goals. This crucial dependence was given formal recognition by the European Council in December 2008 and reaffirmed in December 2009, when the Council invited Member States and the Commission 'to initiate during 2010 forward-looking activities ("foresight") to support the identification of grand challenges and the corresponding priorities for research and innovation' ([6]).

Increasing recognition of the need for better quality FLAs has lead first to the creation of the European Foresight Platform under the seventh framework programme (FP7) and subsequently to the commitment within the 'Innovation Union' to 'create a European Forum on Forward-looking Activities' bringing together existing studies and data and involving public and private stakeholders to improve the evidence base of policies ([7]) and which appears to be a priority of the Polish EU Council Presidency over the second half of 2011.

(6) Conclusions on guidance on future priorities for European research and research-based innovation, European Council, Brussels, 3 December 2009.

(7) European Commission, 'Europe 2020 flagship initiative Innovation Union', COM(2010) 546.

Rémi Lallement – Centre d'Analyse Stratégique – French Prime Minister

Simone Ehrenberg-Silies – VDI/VDE Innovation on behalf of German BMBF

Sergio Jimenez – Spanish observator of Industrial Technology (OPTI)

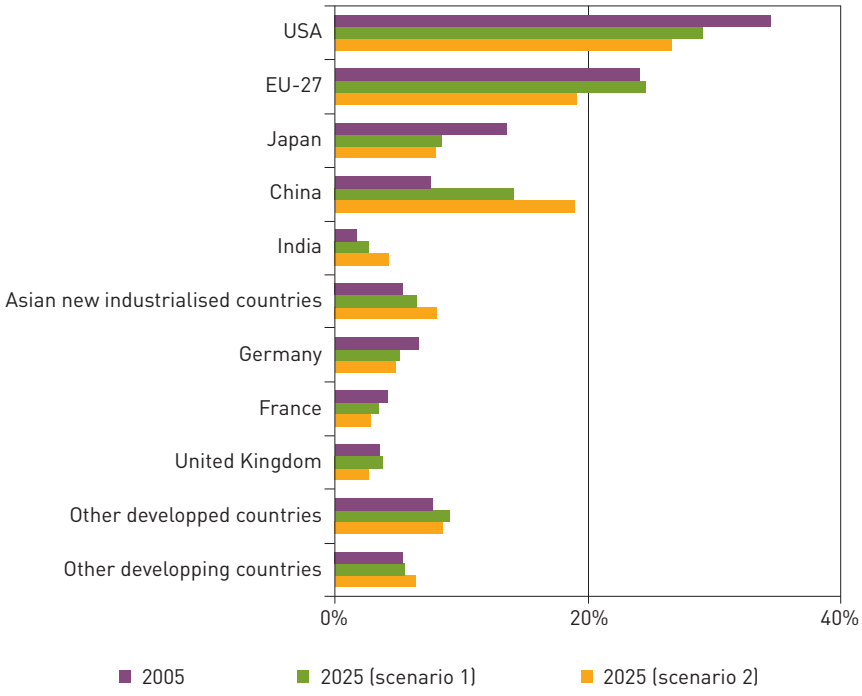
What recent national forward-looking activities tell us about the future of science and technology

Europe must work hard to maintain its strong position in international research, development and innovation

This was a clear message from the presentation of Rémi Lallement from the Centre d'analyse stratégique (CAS).

The study 'France 2025' ([8]) recognises that a new geography of research and innovation activities is being rapidly created. The emergence of new players like China and India will change the landscape in the domain of R & D and future technological breakthroughs could occur in such countries. Figure 1 shows the relative weight of (groups of) countries in the total world expenditure on R & D and the prospect over the period 2005–25 according to two scenarios that are differentiated by changes in the ratio of expenditure on RDI to GDP across the groups. Europe's world share could fall from around 30 % at the end of the 1990s to 20 % by 2025. China could overtake the EU by 2025 (in scenario 2).

Figure 1: Relative weight of investment in R & D (2005–25)



Source: France 2025, CAS, 2009.

(8) 'France 2025', Centre d'analyse stratégique, 2009.

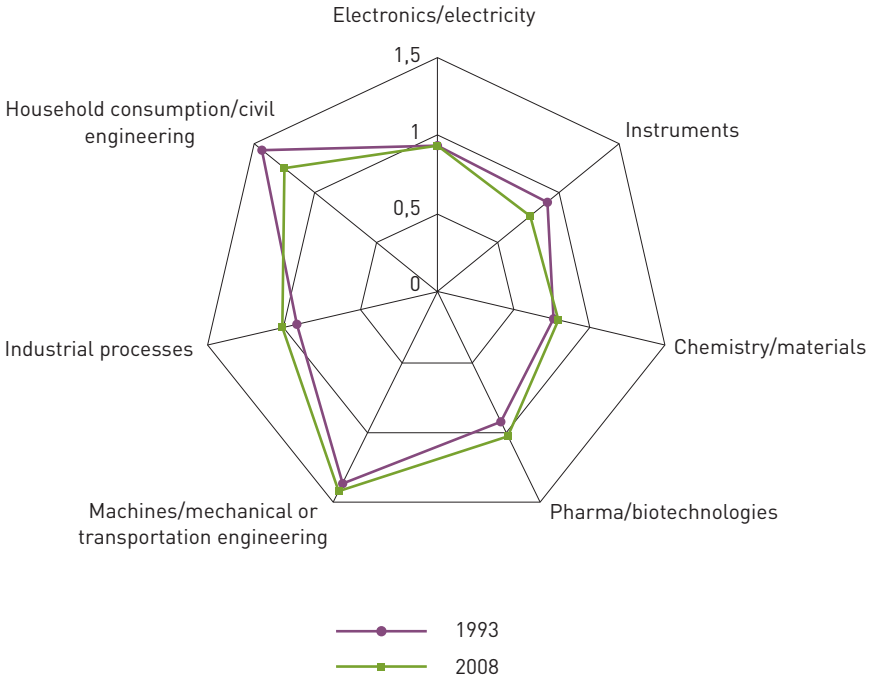
France is fairly close to the OECD (Organisation for Economic Cooperation and Development) and EU averages and its performance has been fairly stable over the past 10 years. R & D expenditure by business has increased rather slowly, mainly because of the erosion of the manufacturing industry that accounts for 85 % of business expenditure in R & D. In general, although R & D intensity has improved slightly, it has oscillated over the period 2000–10, and has not reached the Barcelona target of the Lisbon goal of 3 % in 2010.

There continues to be limited private sector participation in R & D financing. According to an estimate by FutuRIS, the increase in the R & D intensity between 2007 and 2010 is essentially a consequence of fiscal measures, largely the reform of the French research tax credit (*Crédit d'impôt recherche* or *CIR*) in 2008. It may be questioned whether this level of private R & D expenditure (and public financing) is sustainable after 2010, in the aftermath of the financial and economic crisis.

France exhibits, along with some other European countries such as the UK and Germany, a declining share of scientific publications worldwide, mainly because of the very rapid penetration of Chinese scientists into the world literature. A few countries (Italy, Spain, Poland) show some evidence of convergence from a lower base. Within the bibliometric indicators, France enjoys a strong specialisation in mathematics and in sciences of the universe but exhibits a relatively weak performance in applied biology-ecology; this pattern has been fairly stable over the past 15 years.

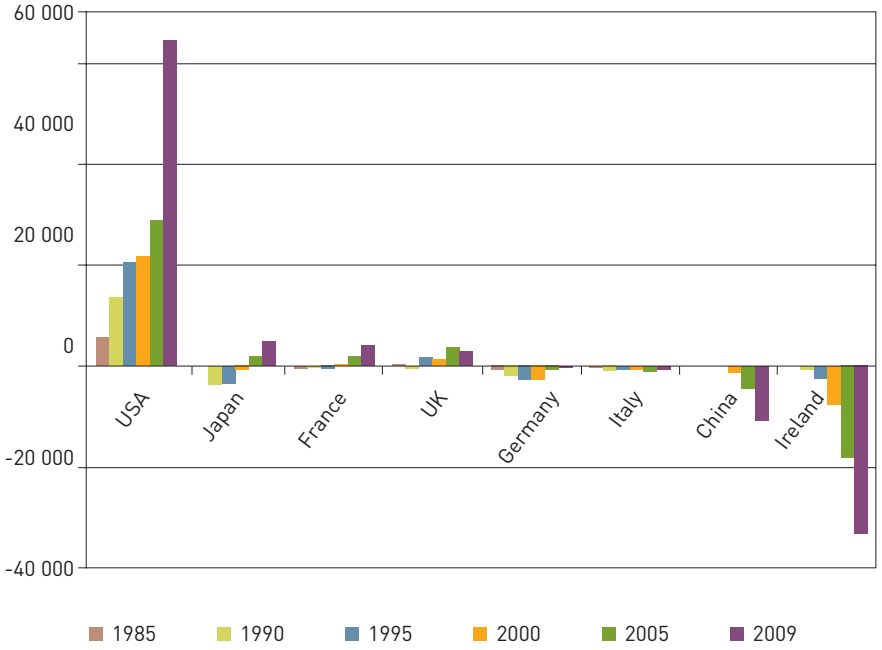
The story with patents is somewhat similar. As in the case of scientific publications, a declining trend is registered for most European countries in relative terms, in large part as a consequence of the growing share of emerging countries. There has been a stronger decline in USPTO patents than in EPO patents. France shows a strong specialisation in the domains of household consumption/civil engineering and machines/mechanical engineering/transportation; it is weaker in chemistry/materials and instruments. Figure 2 shows the specialisation index of France in various technological domains in 1993 and 2008 as measured by EPO patents.

Figure 2: Specialisation index of France 1993 and 2008



It is increasingly apparent that scientific publications and patents do not tell the whole story about the dynamics of international RDI. The balance of technology payments shows a much less favourable evolution of emerging economies. Transnational corporations with local affiliates in emerging economies import large amounts of technology from their parent companies; these exchanges are creating growing imbalances, characterised by a huge US surplus and rising deficits in countries like China and Ireland. Surprisingly Germany also is in deficit by this measure as shown in Figure 3, which indicates how net royalty and licence fees in current million USD have evolved since 1985. A priority of emerging economies is to escape this dependence and it should not be assumed that it will last.

Figure 3: Net royalty and licence fees for selected countries since 1985 (million USD)



France and the EU must react to this radically changing international context through major qualitative shifts in the innovation regime and in the science and technology landscape. A new paradigm is needed for the way innovation activities are to be organised.

- The old model of closed innovation planned by the public sector and led by large national firms in domains like nuclear, aerospace, telecom or rail-road industry has served well, but will not be fit for the purposes of many future challenges.
- A new model of open, collaborative innovation driven by users has to be developed that recognises the key role of innovative 'ecosystems' that encompass the complexity of real life; innovation does not just happen in a laboratory, it is affected by social, economic and cultural forces that need to be understood and harnessed.
- Clusters of innovative firms bringing different skills to bear on common societal challenges need to be developed and regions strengthened in their innovative capacity; the capital region Île-de-France still represents 35 to 40 % of the French science and technology potential.

- The increasing importance of the European level (European Research Area) must be recognised and strengthened.

France is beginning to construct a new public policy aiming at promoting innovation, the knowledge-based economy and structural change. The *Emprunt national* (launched in 2010) is part of this attempt to increase the economic growth potential and to accelerate structural change by boosting the research and higher education system and by promoting key technological domains.

The *Emprunt national* is a framework through which investments of EUR 60 to 70 billion will be directed at innovative projects. It is constructed around a EUR 35 billion public loan that will be disbursed mainly through calls for tender. It will focus on nine priority axes: higher education and public research (EUR 12 billion), training (EUR 1.1 billion), the digital economy (EUR 4.5 billion), energy/recycling (EUR 3.6 billion), clusters and firm financing (EUR 3.09 billion), biotechnologies (EUR 2.4 billion), transport (EUR 3 billion), housing/urbanism (EUR 1.5 billion), technology transfer and commercialisation of public research results (EUR 3.45 billion).

The case of digital technologies illustrates well the kind of challenges that need to be faced in order to reap the potential of technological change in a manner that matches the needs of users. High-performance computing applications play a strategic role at the state level in defence and security and will be a key determinant of competitiveness and innovation in industrial applications and in meeting societal needs. They will be vital across the economy for manufacturing, energy, health, industry, knowledge, analysis and risk prevention, entertainment, culture, planning and sustainable development.

The traditional technological domains of computer science, telecommunication devices and nanotechnologies are rapidly converging and offer immense potential. The main drivers are miniaturisation (Moore's law), standardisation, convergence, very high-speed broadband, diffusion of uses, concentration. Tomorrow's models in the domain of high-performance computing will require online solutions, must satisfy various and numerous users and will transform software into services on a pay-as-you-go basis.

This radical new model implies an enormous change of perception of use: the basic user is no longer a firm or a single person but society as a whole. An example of a social use could be the manner in which high-performance computing can underpin a system of assisted autonomy for older people. The future key to success will not lie in the design and manufacture of components but much more within the systems. The major challenge therefore relies in the design of innovating systems; this is a domain where Europe has many competencies (system and network design, human resources with integration skills).

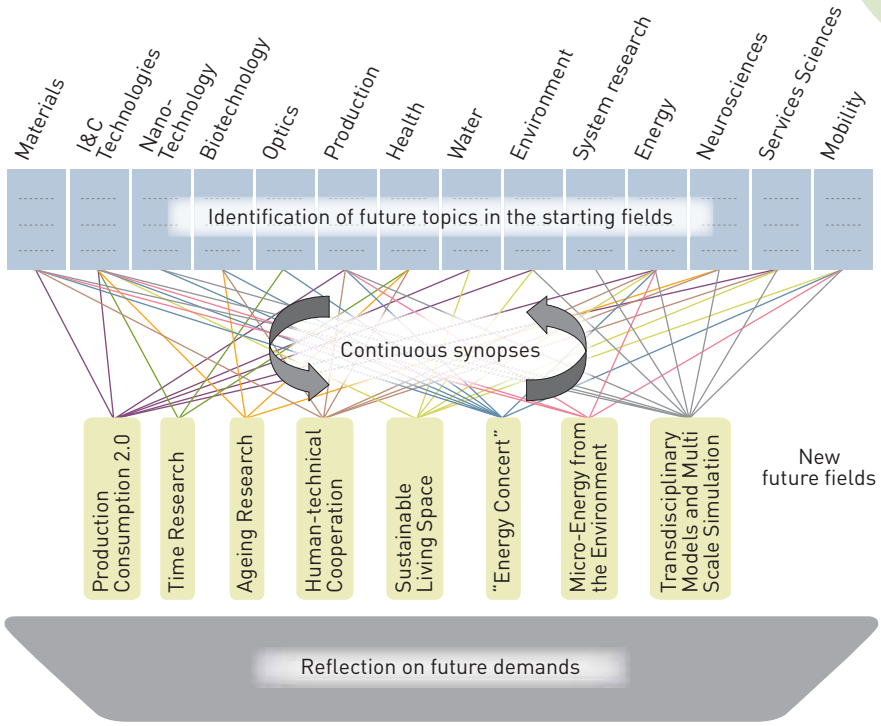
Research priorities can no longer be formulated in terms of areas of technical interest, but must demonstrably address social needs

This idea is of course at the heart of the 'Innovation Union'. A fine example of how Member States are putting this into action is given by the foresight process of BMBF. Which areas of research will be important in the long term? Which topics can be thoroughly dealt with in Germany because they fit in with German science and business skills? Which research and technology areas have enough synergies and influential impact to enable them to provide an impetus in other areas? Which future fields cover a range of disciplines, promise outstanding, pioneering science and technology knowledge gains, and will therefore contribute significantly to people's quality of life and to sustainable resources use? These are the questions posed in the introduction to the presentation at the seminar by Simone Ehrenberg-Silies from VDI/VDE Innovation.

The BMBF foresight process ([9]) began with a specification of 14 starting fields covering the full range of research areas. Experts identified within these fields a set of important future topics by a process that adopted a variety of methods including peer opinion, surveys and horizon scanning. Emerging topics were clustered and re-evaluated according to stringent criteria to select topics that would still be on the research and technology agenda 10 years hence. Only those future topics that could cover a presumed need were considered for further development. In this way the starting fields characterised by 'technology push' were transformed through a long and iterative process to new future fields drawing upon traditional research priorities to construct new vehicles designed to address identified societal challenges. Figure 4 indicates schematically the process.

(9) Fraunhofer ISI and IAO, *Foresight process*, August 2009.

Figure 4: Starting fields and future fields in the BMDF foresight process



- Human–technology cooperation
- Deciphering ageing
- Sustainable living spaces
- ProductionConsumption2.0
- Transdisciplinary models and multi-scale simulation
- Time research
- Sustainable energy solutions

Some of these new fields are self-explanatory; a few require a little explanation. The future field of 'human–technology cooperation' responds to the realisation that technology and society evolve together; the products of technology shape individual perceptions and the ability to act. Reflective technological development is required in order to shape this process in a desirable way. To bring this about requires creation of a social discourse about desirable developmental paths and a new type of research that integrates knowledge from the humanities and social sciences with the technical sciences to facilitate desired

developments. This future field provides a good illustration of how drivers from a wide range of established research lines will help shape future solutions. For example, it will be necessary to draw upon: the availability of large amounts of information; the ability of machines to interpret information; better knowledge of the human brain; real-time processing of large masses of information; greater integration of different components in the smallest space; wireless networking and ubiquitous embedding of systems; greatly improved pattern recognition algorithms; broader access to satellite-supported positioning.

The future field of 'ProductionConsumption2.0' aims to establish long-term sustainable patterns of production and consumption; it includes research into new ways of matching production to social needs in the face of changing basic global conditions while respecting the imperative to maintain the ecosphere.

'Time research' is predicated on the perception that time is not yet adequately understood and that this ignorance is a critical impediment to many potentially favourable developments. Research into time would include analysis of the chronological order of complex processes and how to make applications faster and more efficient, more cost-effective and intelligent, or in parallelising and synchronising processes such as Internet servers and production processes.

Table 1 shows how these future fields map on to the selection criteria.

Table 1: New future fields and selection criteria

Future fields	Knowledge gains	Providing impetus	Economy	Quality of life	Environment
Ageing Deciphering	X			X	
Energy Concert			X		X
Human-Technology Cooperation			X	X	
Micro-Energy		X	X		
ProductionConsumption2.0			X		X
Transdiciplinary Models and Multi-Scale Simulation	X	X			
Time Research		X		X	
Sustainable Living Spaces				X	X

Each new future field will need a tailor-made implementation concept using several implementation instruments, individually adjusted to the respective challenges. The instruments available include: workshops to consolidate understanding; strategic dialogues with those actors in politics, science,

industry and society whose support is needed; future projects in combination with the high-tech strategy; a tracking system.

The strategic dialogues are central tools of the implementation process; their purpose is to support the BMBF in anticipating and integrating results of the foresight process in funding policy measures. Among the functions of these dialogues are:

- evaluation of the foresight results, identification of possible conclusions;
- determination of the framework conditions for promoting the new cutting-edge fields;
- identification of (economic, technological, social) obstacles to implementation;
- definition of the impact on young scientists;
- assessment of the relevance for initial and continuing training;
- identification of ethical and legal aspects;
- assessment of consequences for and needs of society — both for general/specific groups.

Initial progress in implementation of the results of this foresight activity includes: setting-up of the human–technology cooperation division in the BMBF; creation of a narrative scenario of the 'City of tomorrow' (with the working title: 'Carbon dioxide neutral, energy efficient and climate adjusted city') and initiation of a strategic dialogue on ProductionConsumption 2.0.

Forward-looking activities for RDI must help enhance the competitiveness of industry and promote regional development

The work of the Spanish Observatory of Industrial Technology (OPTI) — introduced by Sergio Jimenez — gives high priority to the industrial and regional aspects of RDI. Mr Jimenez stressed just how fast the world is changing and the demands that this rate of change places on our capacity to anticipate what might happen next. Technological change, innovation and globalisation create opportunities, but new fears are also emerging in society, like the financial and economic crisis, a future lack of resources, the consequences of growing inequalities. So rapid is change that finally knowledge is the most important asset that any organisation has to be more competitive. Forward-looking activities try to deal with the future; they try to understand how science, technology and society will evolve and the manner in which that long-term vision of change

can help formulate actions today. Foresight can help build a better future by reducing uncertainty and making better decisions.

What does the Spanish experience of national forward-looking activities tell us about science and technology trends? There are three fundamental classes of achievement.

- FLAs have helped Spain to design national science policy.
- They support industrial competitiveness in complex environments.
- A better understanding of trends is also indispensable for the study of regional development and transregional cooperation.

For the development of the current Spanish science plan, OPTI worked jointly with the Spanish Ministry of Science to carry out the biggest foresight exercise so far conducted in Spain. The national research plan that was the result of the exercise is now the main tool of the science and technology policy for research funding, operating through public calls in relevant topics. This is the first time in Spain that a foresight process has been used to establish priority lines of research in a national science plan.

OPTI identified 12 fields of knowledge of interest; for each area, panels of highly experienced professionals were constituted and charged to design a Delphi questionnaire. More than 2 700 experts from all scientific and technological backgrounds participated in the survey and more than 200 experts contributed to the analysis. Five strategic actions were identified for critical fields, i.e. health, nanotechnology, energy, ICT and biotechnology; within each topic different research lines were identified. For example, in biotechnology these were: biotechnology for health, biotechnology for agrofood, industrial biotechnology, biofuels, biotechnology and environment. This exercise showed that the science and technology trends can support the design of policies in all aspects, including for human resources, education and international cooperation.

A complementary foresight exercise, focused more on innovation than on basic research, was made in 2010 for the Ministry of Industry. The study was motivated by the poor economic situation and the lack of competitiveness of some Spanish industrial sectors. The aim was to identify suitable industrial and technological opportunities for future development of the Spanish economy and to help affected industries identify innovation activities that would permit them to develop new products, processes, services or even new markets and thereby to strengthen their competitiveness, productivity and international reach. Fourteen areas of high relevance were identified, including agrofood, automotive and railway industries, renewable energies and water. These areas were selected because the technological and industrial capabilities were considered sufficient to constitute strategic sectors for the economy of the country.

FLAs identified the technological trends that could be considered of higher relevance in the mid-term. The process that was adopted brought experts to confront the possible future technical alternatives with the commercial reality of the industrial sector. Then by a pseudo-roadmapping process, industrial and technological development opportunities were identified, along with the necessary actions to reach the future visions in the desired time horizon. With the collaboration of 200 experts, 87 development opportunities were identified as working opportunities for innovation and training in new areas. Fifteen opportunities and 12 strategic actions were proposed to the Ministry of Industry as worthy of support in the development of new related policies. As an example, the opportunities identified for agrofood were:

- new products' development ensuring food security, and nutritional and organoleptic characteristics;
- biotechnology applied to the food chain;
- agrofood auxiliary industry specialisation;
- new materials and packaging designs.

For each of the opportunities, objectives were defined, barriers identified and actions proposed that would achieve the vision of the future. This experience shows how the long-term strategic thinking inherent in FLAs can help affected industries reposition their activities in a highly competitive and dynamic global environment.

Foresight activities have also been deployed in regional development policy. In 2008, Valencia carried out a foresight exercise involving the main technological actors of the region. For eight strategic sectors, technology trends that could influence socioeconomic development were analysed and regional actions were defined to promote the areas in which innovation could make better use of existing resources. The knowledge and excellence in transversal technologies made it possible to redraw the competences map, opening traditional sectors to 'hypersectors' of higher influence.

Work to understand technology trends can also boost cooperation between different countries. The region of Navarra carried out a joint foresight exercise with similar regions in Italy and the UK (Lombardy, East London) to identify promising areas of science and technology and to develop a cooperation roadmap with the horizon of 2020 that would support innovation and increase personal mobility between regions with common interests, so better to plan and achieve regional innovation systems.

Marek Tiits – Institute of Baltic Studies (IBS)

Rafael Popper – Manchester Institute of Innovation Research (MIoIR)

Domenico Rossetti, Perla Srour-Gandon – EC, DG Research and Innovation

Innovation will renew the economy and will create employment and well-being

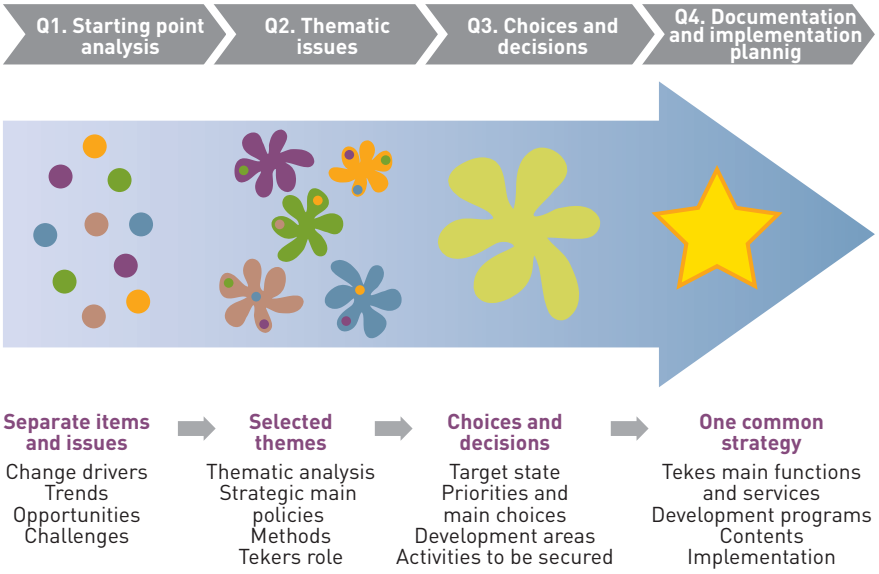
Recent Finnish experience is revealing of how knowledge can transform an economy.

Thirty or forty years ago, Finland was a primary economy relying mainly on resource-intensive industries; it is now a highly specialised economy in ICT and services. The World Bank, in drawing lessons from this achievement, concluded that flexibility in responding to change and a responsive education system were critical factors along with the capacity of the country to create a common vision and a process for consensus building ([10]). All these factors are a part of foresight.

FinnSight 2015, a joint project between the Academy of Finland and Tekes, the Finnish Funding Agency for Technology and Innovation, was completed in 2006; it was designed to identify the main focus areas in science, technology, business and industry, and society. The areas that emerged most prominently were: the management of global risks; energy and environment issues; the renewal of the healthcare system as well as ICT and biosciences' applications. These areas have in common the requirement for science and technology collaboration based on human needs. The report underlined also the importance of education in fostering the necessary competencies and the scientific basic research. This foresight exercise laid the foundation for subsequent strategic work at Tekes. The strategy and policies of Tekes are updated every three years through a foresight exercise. The methodology comprises an iterative cycle of foresight, scenario building and elucidation of strategic priorities within a large consultative element. The main thrust of the process is captured in Figure 5.

(10) *Finland as a knowledge economy: Elements of success and lessons learned*, World Bank, Washington, 2005.

Figure 5: The dynamics of the strategy process



Implementation is through projects, programmes and very importantly through the Strategic Centres for Science, Technology and Innovation (SHOKs), established in Finland as public-private partnerships to accelerate innovation and to renew industrial clusters. They are charged to develop and apply new methods for cooperation, co-creation and interaction. Companies and research units work in close cooperation on research issues that have been jointly defined in the strategic research agenda of each centre to match the needs of Finnish industry and society over 5 to 10 years. Six centres are in operation:

- Forest cluster: Forestcluster Ltd
- Information and communication industry and services: TIVIT Ltd
- Metal products and mechanical engineering: FIMECC Ltd
- Energy and the environment: CLEEN Ltd
- Built environment innovations: RYM Ltd
- Health and well-being: SalWe Ltd

The overall goal of the current Tekes strategy according to Riikka Heikinheimo is 'growth and well-being from renewal'. The demand for renewal is predicated on a range of global and social challenges. The global division of labour is changing and operations are moving to global value networks; technologies will advance and be transferred rapidly around the world. At the same time, social structures will change as a consequence of urbanisation and the ageing

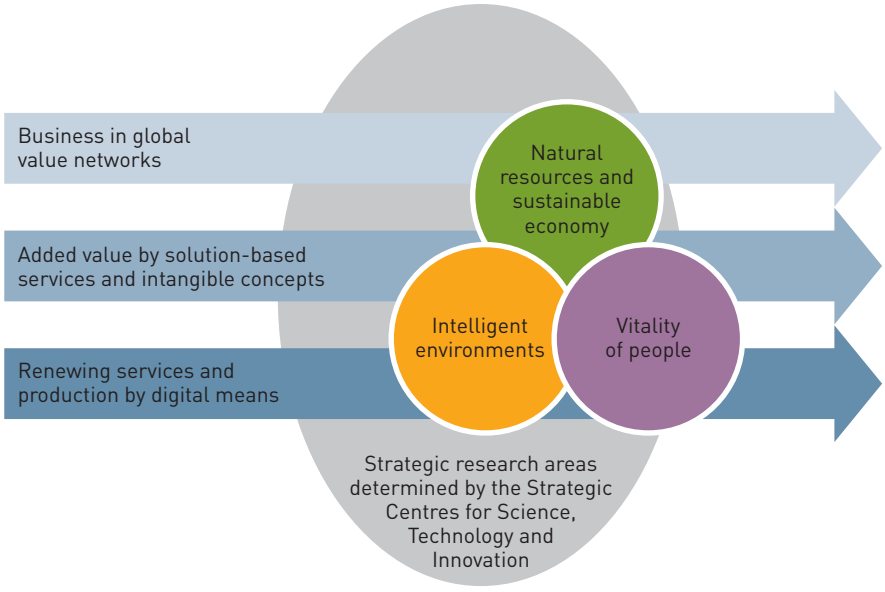
of industrial countries. A demand for environmentally friendly solutions will grow, as will demand for tailored and individual solutions, driven by demanding end users and user groups. Development will be guided by usability and user experience; technology will be less determinant.

Within this goal of growth and well-being from renewal the main focus areas are:

- presence in global value chains;
- added value by solution-based value network resources and intangible concepts;
- renewing services and production by digital means;
- natural resources and sustainable economy;
- intelligent environments;
- the vitality of people.

The interrelationships between these concerns and the implementation through the SHOKs are shown schematically in Figure 6.

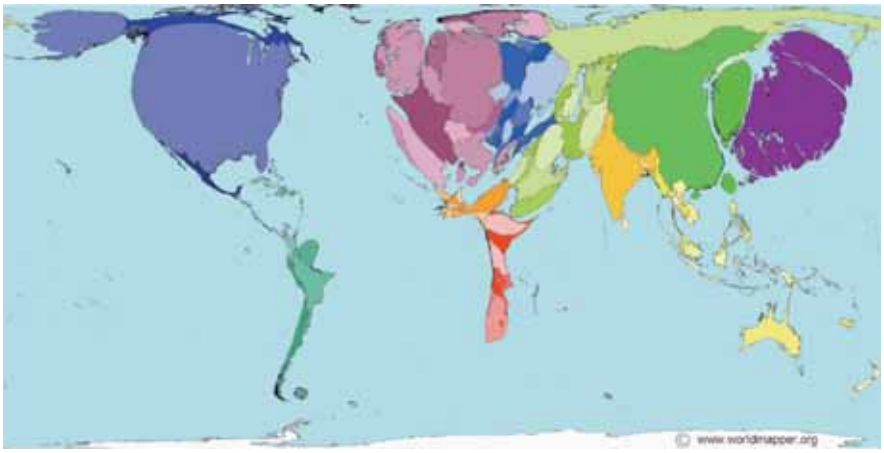
Figure 6: Focus areas of the Tekes strategy



Small countries need to position themselves carefully in a strongly competitive global market

The problems that face smaller countries in competing in the future global environment differ in important respects from those of the big countries of the EU. There are fewer world class resources on which to build and perhaps more ground to be made up before innovation can begin. To make this point, Marek Tiits of the Institute of Baltic Studies in Estonia showed a map of the world (Figure 7) in which the areas of countries were shown proportionally to the numbers of people employed in research ([11]). On this map some countries of Europe are scarcely visible.

Figure 7: Research and development employees



One of the key areas of study in the IBS is how companies, regions, states and meta-regions such as the Baltic Sea region or the European Union are able to maintain and increase their competitiveness in an ever-changing world. The turn of the 21st century is the time of an ICT revolution and for Estonia it is vital to find a niche within this landscape where the country can benefit most effectively from these profound structural changes. The IBS therefore has conducted a major study entitled 'EST_IT@2018' to position Estonia securely in this market by 2018 ([12]). Preparation of the foresight exercise started in early 2008; it began to gather technological intelligence on main global trends in ICTs and to establish a shared vision on the future contribution of ICT to the development of the Estonian economy and society. Estonia is not equipped

(11) SASI Group (University of Sheffield) and Mark Newman (University of Michigan).
(12) See also: *ICT sector in Estonia: Foresight study*, IBS, September 2008.

to compete with the United States, Japan and major EU countries in component and system development in ICT or in other technology domains. The main opportunity and challenge for small, catching-up economies like Estonia is rather to be an early and active user of technologies developed elsewhere, and to be very closely and favourably integrated into various international business alliances so that the ICT applications piloted domestically can be exported promptly to international markets. The initial scoping phase of the foresight process was constructed to recognise this constraint.

An extensive process of brainstorming and consultation followed the scoping exercise in which the goal was to assess Estonia's competences and domestic barriers to change, and what the prospects for growth of international demand for related ICT solutions were. The focus areas for application of novel ICT solutions were identified:

- financial services and ICT security systems;
- education;
- manufacturing;
- energy supply and energy efficiency;
- healthcare.

This mapping of competences will provide an input to related higher education and research in Estonia. The analysis of socioeconomic trends will be the basis for development of focused roadmaps and investment plans.

The 'EST_IT@2018' foresight exercise offered two broad lines of policy recommendations.

- Firstly, it advocated that Estonia needs to significantly strengthen higher education and good public research in ICT by attracting strong academics from abroad while supporting more actively the studies of Estonian postgraduate students abroad.
- Secondly, it highlights the importance of proactive and more selective foreign direct investment policy and intelligent execution of lead market initiatives and more systematic use of public procurement as the means of modern innovation policy.

In this context the framework programme could potentially be of value in strengthening research in Estonia. However, as the framework programme is a merit-driven process it channels funds to countries and institutions that are already well ahead. The EU regional and cohesion policy should be adapted to compensate for uneven capacities in RDI across Europe. The question arises as to whether the future EU research and innovation policies and programmes can support a more equitable development of RDI capabilities and industrial upgrading.

There is divergence in national priorities, but also strong elements of convergence on transformative priorities that integrate social and technical research with participatory processes

Several national FLAs in the domain of RDI were reviewed in a paper by Philine Warnke of Fraunhofer ISI; the analysis covered nine European national forward-looking studies conducted between 2007 and 2011 with different time horizons, focus areas and approaches ([13]). Some used large-scale participation (Denmark, the Netherlands ([14])), others focused more on core actors (UK ([15]), the Flanders region of Belgium ([16]), Germany ([17])). Some studies aimed to identify pathways or scenarios of change within a period (Poland ([18]), Ireland ([19])); others rather tried to detect signals of change (Finland ([20]), the Netherlands); the remainder sought to collect and assess proposals for RDI topics (Denmark, Luxembourg ([21]), France ([22])).

The studies are also differentiated by scope. Those of Spain ([23]) and the Flanders region assessed mainly technological trends; 'France 2025', 'Poland 2020' and the Polish study adopted a broad perspective of socioeconomic change and its consequences for research and innovation. The studies of BMBF in Germany and the Horizon Scan Report in the Netherlands emphasised transitions from established realms of research and innovation to work that addressed expected societal challenges of the future.

Most of the studies do not explicitly set out to define grand challenges; rather they adopt them from extant documents, but they tend to concur that the need to address global challenges is an important rationale for RDI priority setting. They adopt a mix of selection criteria combining competitiveness and

(13) *Towards transformative innovation priorities: Synthesis of findings from forward-looking studies across Europe*, Philine Warnke, Fraunhofer ISI, Karlsruhe, February 2011.
(14) *Horizon Scan Report 2007: Towards a future oriented policy and knowledge agenda*.
(15) *Technology and innovation futures: UK growth opportunities for the 2020s*.
(16) *Technology and innovation in Flanders: Priorities. Summary report and recommendations*.
(17) Fraunhofer ISI and IAO, *Foresight process*, August 2009.
(18) Edwin Bendyk, *Poland 2020. A look from the future. Alternative visions of Poland's development based on the National Foresight Programme Poland 2020 scenarios*.
(19) *Sharing our future: Ireland 2025 — Strategic policy requirements for enterprise development*.
(20) http://www.foresight.fi/
(21) FNR Foresight, *Thinking for the future today* (http://www.fnrforesight.lu/).
(22) *Étude Technologies clés 2010* (http://www.industrie.gouv.fr/techno_cles_2010/html/sommaire.php).
(23) Estrategia Nacional de Ciencia y Tecnología (ENCYT) 2020. Ejercicio de Prospectiva a 2020.

challenge-oriented criteria; the need to obtain an advantage over competing economies is a recurring theme:

- securing energy supply and decarbonising energy production;
- counteracting climate change;
- preserving biodiversity;
- food safety and security;
- preserving ecosystem services/securing clean environment;
- adapting to climate change;
- securing water supply;
- combating chronic and infectious diseases;
- handling global conflicts;
- understanding and dealing with changes in social fabric, in particular demographic change but also diversity;
- ensuring well-being and quality of life;
- ensuring resource security.

Strongly relevant to the theme of this seminar is the analysis in the paper of the cross-cutting areas of research and innovation activities that combine several technological domains. This analysis is summarised in Table 2.

Table 2: Cross-cutting RDI priority areas suggested by the studies

Cross-cutting R & D priority area	Source	Core approach
Two related transitions: creating and utilising space	NL Horizon Scan	Making good use of limited space and possibly make new space available. New roles for urban and rural space.
Manufacturing on demand	UK TIF	Distributed local manufacturing of personalised products with rapid manufacturing technologies and new business and service models.
Accelerating the development of new energy sources	NL Horizon Scan	New forms of extracting, storing energy and transition to adequate infrastructure.
The energy transition	UK TIF	Decarbonisation of energy. New sources, new storing, new distribution facilities, new services.
Smart infrastructure	UK TIF	Intelligent transformation of electricity and other infrastructure with sensors and meters to meet future demands.

ProductionConsumption2.0	BMBF-Foresight	Systemic socio-technical innovation towards sustainable patterns of production and consumption. Focus on critical bifurcations of production and consumption. Including methods for moderating and sustainability transitions.
Human–Technology cooperation	BMBF-Foresight	Transdisciplinary research on new formations of humans and technology from individual level up to socio-cultural perspective.
Living spaces of the future	BMBF-Foresight	Concepts for urban and rural space accommodating the changing requirements of future generations.
Energy concert	BMBF-Foresight	Meta-analysis of contribution of diverse technology lines to energy efficiency.
Infrastructures for the future	NL Horizon Scan	How can we shape infrastructural facilities so that they fit better with new and future desires and demands? Infrastructural breakthrough through new coupling of hard and soft infrastructure.
Local cycles and future of the countryside	Foresight.fi	Exploring possible futures for the countryside such as local cycles of production, consumption or well-being and recreation.
Robotics and interconnectivity	NL Horizon Scan	Implication of robotics and intelligent systems for humans, society and social living.
Engineerable human	NL Horizon Scan	Transdisciplinary research on issues of changing human nature and societal responses in the face of medico-technical research.
Sustainable resource management	FNR	Sustainable territorial development in urban and rural areas, integrative and holistic understanding of energy and material flows in Luxembourg, agro-systems management, ecosystems and biodiversity.
Sustainable transport and infrastructure	Forsk2015	Sustainable transport systems and solutions.
Better life space — space for life and growth	Forsk2015	Progressive coupling of urban development, physical planning and social progress.
Changing lives	Forsk2015	Fundamental knowledge of the opportunities and needs of different age groups.
Energy systems of the future	Forsk2015	Developing competitive, energy-efficient and sustainable energy systems that can satisfy future energy demands and environmental requirements.
Bio-resource based production	Forsk2015	The research is directed at the health and well-being of animals and people and at the interaction of bioproduction with the surrounding society, environment and biological diversity.
What does the 'greying' of society mean?	NL Horizon scan	Understanding socio-cultural change in an ageing society.

Further analysis and clustering identifies a reduced set of transformative priorities that align social and technological breakthroughs in innovation and that will require research across engineering, natural and social sciences as well as humanities:

- energy transition (developing competitive, energy-efficient and sustainable energy systems that can satisfy future energy demands and environmental requirements);
- bio-resource management (sustainable management of bio-resources for food, health, energy and materials);
- sustainable patterns of production and consumption;
- human–technology continuum (exploring new types of high-quality human–technology interaction);
- infrastructure transition (pathways for sustainable infrastructure transition (transport, energy, housing, water);
- living spaces (sustainable patterns of rural and urban living).

The analysis concludes that there is a high degree of congruence with the grand challenges as conceived in the Lund Declaration and the 'Innovation Union'. The definitions of the transformative priorities could nonetheless benefit from more reflection in particular as to whether other modes of clustering might generate higher European value added. However defined, it is apparent that there will be strong linkages among the members of any set of grand societal challenges; mechanisms need to be found to ensure effective communication between RDI in the different domains.

There is a danger in trying to force RDI along a single path that does not recognise the very wide cultural and environmental diversity of Europe. The interpretation of what constitutes sustainable patterns of rural and urban living will vary widely across the Union depending on climate, culture, history and a range of contingent events.

Transformative breakthroughs are characterised by intimate integration of social and technical thinking. To do this successfully will require new coalitions and participatory processes involving not only researchers and engineers but also users and citizens. They cannot be created by exclusively top-down priority setting.

Luke Georghiou – Manchester Institute of Innovation Research (MIoIR)

Andrea Ricci – ISIS, Member of EU Expert Group 'Global Europe 2030/2050'

Matthias Weber – AIT, European Foresight Platform

Karl-Heinz Leitner – Austrian Research Center (AIT)

Lars Kluver – The Danish Board of Technology

What EU forward-looking activities tell us about societal challenges that need to be addressed by EU research and innovation

This section reviews the presentations on selected FLAs that have been financed by the EU together with a presentation on the global 'Future agenda' project that was financed by Vodafone.

The 'Social sciences and humanities' programme within the Research and Innovation DG has funded a range of forward-looking activities with a variety of methods and aims. The topics addressed include ([24]):

- science, technology and innovation (FARHORIZON, INFU, SESTI);
- participative horizon scanning (CIVISTI);
- wild cards and weak signals (IKNOW);
- security and defence (SANDERA);
- the world and Europe in the future (AUGUR, Global Europe 2030/2050);
- European Foresight Platform (EFP);
- the future of the Mediterranean area (MEDPRO);
- post-carbon society (PACT, GILDED, PASHMINA).

By the nature of FLAs, all of these projects have some relevance for policy in RDI; some of the most relevant were presented to the seminar and then discussed by participants in subgroups.

FARHORIZON

The aim of the FARHORIZON project is to develop and use foresight techniques to align research with longer-term policy needs in Europe and the range of policy and regulatory competences enjoyed by the European institutions. Luke Georghiou from Manchester University introduced the project, explaining that research in Europe must be conceived as part of a wider ecosystem embracing innovation and other policy domains and many actors within them. FARHORIZON seeks to advance understanding of:

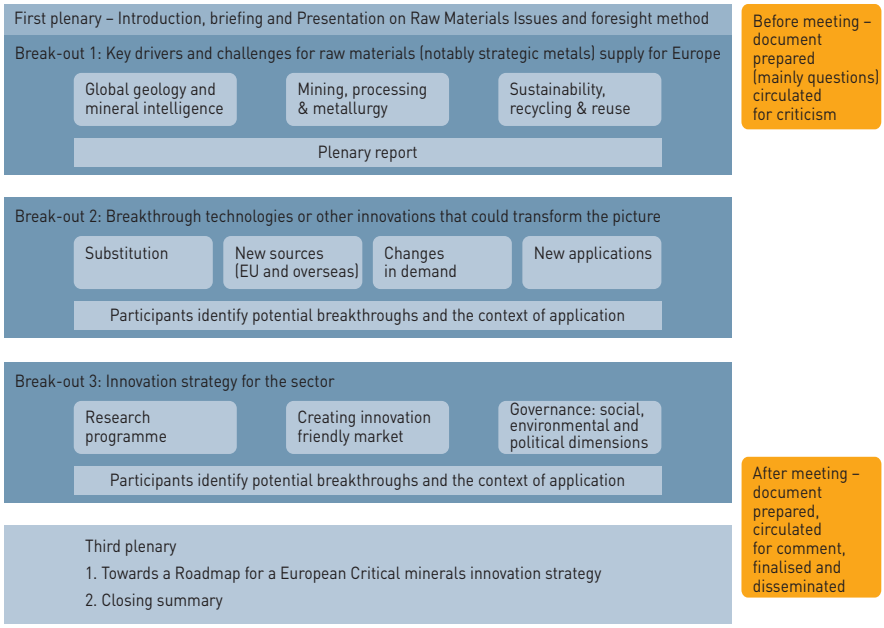
(24) *European forward-looking activities: EU research in foresight and forecast*, European Commission, Research and Innovation DG, 2010. http://ec.europa.eu/research/social-sciences/forward-looking_en.html

- the differences observed across policy domains in the European research and innovation ecosystem in terms of the role and the integration of research agendas in long-term policies and vice-versa; and
- what foresight designs will elicit engagement and secure follow-up across policy domains and areas.

The methodological approach of FARHORIZON centres on the creation of a 'vision of success' or a credible and coherent picture of the future that incorporates 'stretch targets' for all stakeholders and merges different expectations in a coalition of actors to advocate for the vision. This desirable future is compared to the ability of the research and innovation ecosystem in the appropriate technical area to deliver the necessary change; from this comparison, a roadmap is constructed to identify and schedule the actions needed to make the vision real.

Participants are selected to have perceptible influence on policy and strategy, both for plausibility of results and commitment to future actions. Typically a workshop is designed and implemented in cooperation with key institutions from the area and involves 20–30 people; the pilot examples included national representatives up to minister level, Commission staff up to director and cabinet level, senior industrialists and scientists, foresight and innovation experts and some early career researchers. A typical workshop structure is shown in Figure 8, in this example for the case of raw materials.

Figure 8: Typical workshop structure (example of raw materials)



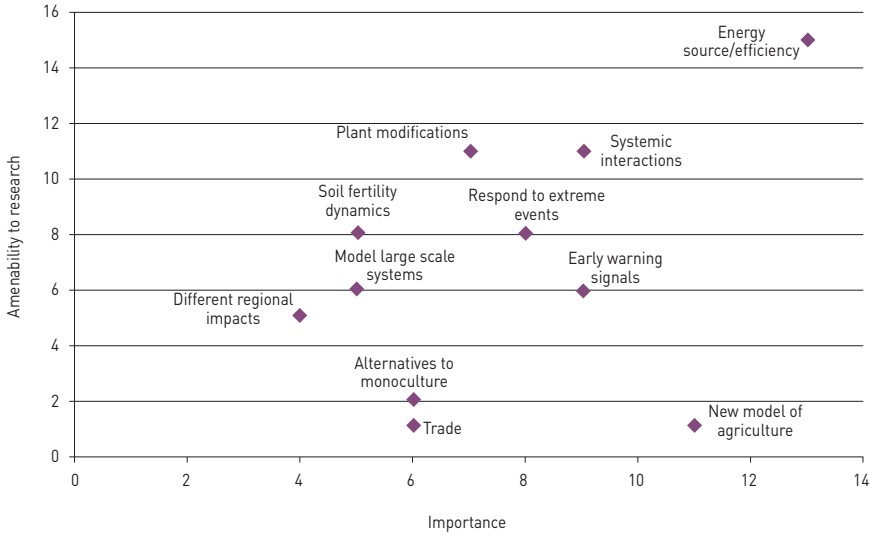
Four topics were selected for pilot studies on the advice of an independent panel:

- agriculture and adaptation to climate change;
- dynamising innovation policy: giving innovation a central role in European policy;
- education in an ICT-revolutionised society;
- breakthrough technologies for the security of supply of critical minerals and metals in the EU economy.

Results from three of these pilots were presented at the workshop. The application to research on the adaptation of agriculture to climate change was made in cooperation with the Standing Committee on Agricultural Research (SCAR). The workshop addressed issues of real policy concern relating to contemporary communications on climate change, previous SCAR foresight work and a joint programming initiative that was then in preparation and has subsequently been adopted. A workshop was conducted with 25 experts from 13 Member States and the Commission including SCAR and CREST members, and agriculture and foresight experts.

The twin aims were to identify breakthrough technologies which could have a major impact upon the capacity of European agriculture to adapt to climate change in agriculture and then to define the research and innovation strategies needed to develop and make use of such technologies. A useful screening tool for identifying priorities is the trade-off diagram shown in Figure 9 that shows the importance of a topic and how amenable it is to research. A topic scoring highly on both counts would normally be a priority for research.

Figure 9: Trade-off diagram of importance against amenability to research



In this case the success scenario encompassed technological and social changes up to 2050 and was reported as a historical account looking back from that date. Three critical changes of technology and management and some 'retrospective comments' were:

- new varieties of plants with reduced need for fertilisers and new varieties of fertilisers from manure and other less energy-intensive sources:
  - 'Nitrogen fixing in grasses was key breakthrough in the early 2020s. Opposition to GM approaches was dissipated when some key concerns of opponents were alleviated by creation of low risk plants (e.g. without the ability to spread pollen)';
- mesh of disposable wireless network mimic sensors for early detection of fungal disease;
- knowledge management to use existing knowledge effectively:
  - 'Much of the plant molecular biology of [the] last decades of [the] 20th century had remained in research silos until an integrated approach to the adaptation challenge unleashed its interdisciplinary potential.'
  - 'Traditional knowledge and old practices proved an important take-off point.'

The second example addressed the question of how to give innovation a central role in European policy. The policy context comprised the debate over the global financial crisis, the Europe 2020 strategy including the flagship 'Innovation Union' initiative and the forthcoming plan for European research and innovation. Key stakeholders were the Enterprise and Research and Innovation DGs, the Taskforce for the Action Plan, the Cabinet and Member States. The aims were to build a vision of success as to how European institutions can take shared responsibility for innovation, addressing not only policies directed at promotion of research and innovation but also sectoral or cross-cutting areas. The workshop participants included 27 senior actors in European research and innovation policy, from the Commission, Member States and other agencies. The workshop identified the three pillars of a future innovation policy shown in Figure 10, comprising: an issue-oriented approach to the grand societal challenges, a systemic innovation policy to manage systemic deficits and a leadership function.

Figure 10: The pillars of innovation policy

Future European innovation policy		
Issue-oriented innovation policy	**Systemic innovation policy**	**Rationales for innovation policy**
Focus on Grand Challenge	Dealing with systemic deficits	Providing vision and leadership

Policy priorities that came out of the workshop included specific actions to:

- link grand challenges to the creation of lead markets;
- improve procurement processes for innovation and attitudes to procurement;
- reinforce and better link existing innovation policy instruments;
- empower public administrators to take more risks and initiatives;
- ensure coherence and clarity in EU strategy and approach to R & I policies;
- develop new instruments such as social challenge innovation platforms, EU-wide clusters and specialisation.

The application to raw materials was designed to examine the growing understanding of the extent and consequences of a European dependence on relatively small quantities of strategically critical minerals such as rare earths. The pilot was developed with the help of the Bureau de Recherches Géologiques et Minières (BRGM) who provided preparatory background material and identified key drivers. Informed by the drivers, participants identified key challenges for Europe and priorities. If these challenges could be met, then a successful vision for the sector in 2030 and its benefits to Europe could be achieved. Challenges are summarised in Table 3.

Table 3: Drivers of the availability of strategic minerals

Geology and minerals intelligence	Mining, ore processing, metallurgy	Sustainable use, efficiency, recycling and reuse
Accessing data on mining, production, geology	Exploiting deeper deposits	Downstream resource efficiency
Acquiring knowledge of deeper resources	Accessing seabed deposits	Better citizens' understanding/ attitude
Improving knowledge models of how deposits are produced	Better health and safety/ predicting seismic events	Building capabilities/training
Better exploration	Using less water/energy	Transforming waste into mines/ urban mining
Systematic data sharing	Reducing CO_2 footprint	More systemic view of different critical minerals
Exploiting 'exhausted' mines	By-product handling	Better use of other resources — water/energy
		Global governance of new extractive activities

Four key actions were identified to bring about the vision of success that was formulated during the workshop.

- Establish a strategy for the area.
- Research, technology and innovation (RTI) with three central aspects:
  (a) focus on improved intelligence on sources; new technologies; mitigation;
  (b) a joint programming approach;
  (c) a 'holistic' approach to the innovation cycle.
- Increase the flow of trained people: drive more universities to develop curricula and make them more attractive.
- Stronger governance: Europe needs to become proactive in all new developments and partnerships, promote sustainable mining, transparency, new initiatives dealing with corporate social responsibility of mining actors.

Global Europe 2030/2050 and PASHMINA

In his presentation Andrea Ricci from the Italian ISIS covered two distinct, but related, pieces of research from the Expert Group 'Global Europe 2030/2050' and the PASHMINA project funded under FP7.

The objective of the Expert Group on Global Europe is to assess and measure the past, present and expected future changes in the world and Europe from a political, economic, social, cultural, environmental and technological perspective up to 2050 and to define plausible transition states. It integrates quantitative and qualitative analyses to connect challenges, visions and options for action in a manner that is intended to overcome the well-known problem of FLAs of ensuring trust; policymakers and the public are often cynical about conclusions based on opaque assumptions manipulated by black-box modelling. Through this process the group has generated a set of alternative scenarios of the world up to 2050 focusing on Europe, identifying the major potential transitions and the potential disruptive factors. The eventual aim is to identify future European research priorities and revision of the governance of research across the European research area (ERA) that will permit preferred transitions to come about and will help create a competitive and sustainable EU. The main classifications of characteristics of the future scenarios that have been adopted are:

- geopolitics and governance: EU borders, integration and role on the global stage;
- demographic and societal issues and challenges;
- energy and natural resources security and efficiency, environment and climate change;

- economic and technological prospects;
- research, education and innovation.

And on this basis three scenarios have been proposed:

- 'Nobody cares: The decline of Europe';
- 'EU under threat: A world of discontinuities';
- 'EU matters: The European renaissance'.

The next step is to move from the qualitative to the quantitative, from narrative to modelling. This poses the problem of parametrisation of policies, how they can be represented in numerical terms.

The expert group will complete the study at the end of 2011 but some insights can be gleaned from a presentation on EU research and innovation priorities given to the expert group in its March 2011 meeting ([25]). The author reflects on the practicality of the target for 3 % GDP and when it might be reached, but more radically muses over the value of R & D expenditure as a relevant indicator for the mid-21st century. Many relevant innovations and changes are occurring outside the R & D function and they are simply not captured by this indicator. Even what constitutes R & D is quite hard to define given the low cost and high availability of ICT tools that enable much innovation by people who are in no conventional sense researchers. Making Europe the largest knowledge economy in the world is in some ways a more tangible indicator for a long-term strategy in science, technology and innovation. Though it is more difficult to define, the concept captures better what seems to be the aim. Use of this as a specification of the goal introduces a difficult obligation to define a 'knowledge economy' and, as a relative target, it will depend on what the others do.

The analysis concludes that Europe could become in 20 to 40 years the world's largest knowledge economy if certain conditions are met.

- The challenge is taken seriously by both the national governments and the European institutions.
- A knowledge generating and distributing central authority is instituted (comparable in powers to the ECB).
- It is properly understood in which directions knowledge generating and distributing is evolving.

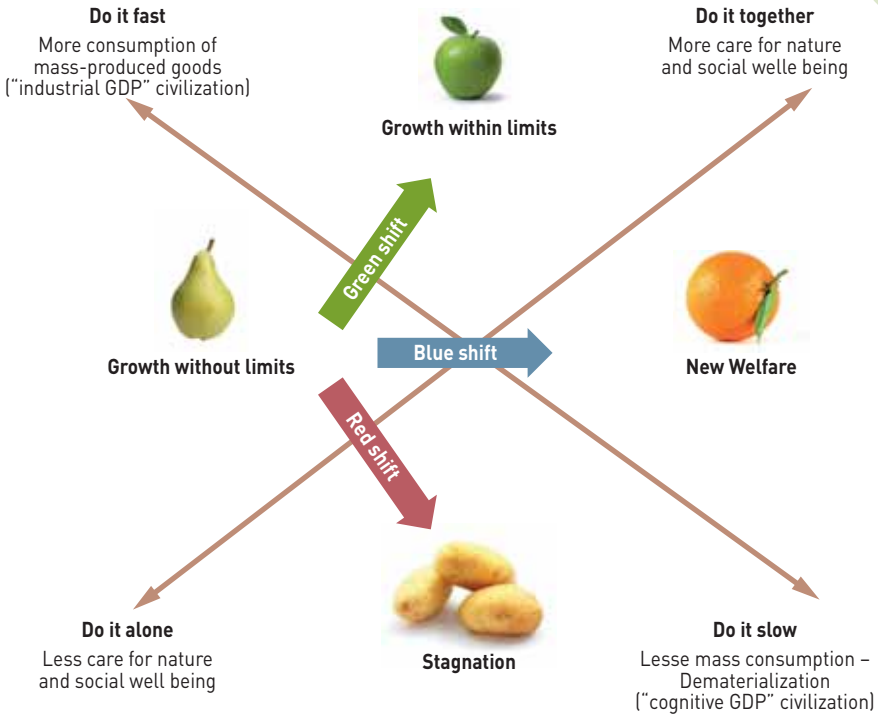
The relationship of European research to international efforts will need to be considered more thoughtfully in the future as emerging economies begin to make their mark on global research. Europe needs to increase cohesion and convergence among EU countries; some EU countries are among world

(25) *A global innovation Europe*, Daniele Archibugi, Brussels, 22 March 2011.

leaders in RDI whereas others lag far behind, but it must achieve this without losing contact with other world leaders and emerging countries. The international dimension of policy should also recognise that European priorities in large part reflect a concern with using wealth to create a sustainable, inclusive and well-serviced society, whereas in emerging economies the emphasis is more upon technologies leading to creating more material wealth. This analysis concludes that if Europe is to be a strong innovating force in the future it must develop and extend the capacity for high-level RDI across its entire space whilst simultaneously remaining open to the scientific and technological opportunities generated abroad.

PASHMINA ('Paradigm shifts' modelling and innovative approaches') also addresses a long-term perspective (2030–50). The project aims to enhance the ability to understand and manage global changes by designing and using a new generation of models with novel indicators of social success and that account better for interactions between the economy and the environment, in particular the relationships between energy, transport and the environment nexus, and land use and territorial functions. It questions the feasibility and desirability of maximising economic growth as a dominant social objective and proposes an alternative ecological economics framework focused on the interaction between economic and ecological systems. Four scenarios are foreseen, defined by two major axes representing rapidity of action and degree of communal effort. They are the 'pear', 'apple', 'orange' and 'potato' scenarios indicated in Figure 11. Each scenario is given a 'totemic' measure of success — that of the BAU scenario (the pear) being GDP. The intent is to understand the actions that are needed to shift from the pear to other possibly preferred scenarios.

Figure 11: PASHMINA scenarios and transitions



Modelling enables numerical predictions by scenario of many economic, social and environmental indicators for six macro-regions of the world. The actions needed to move from one scenario to another have not yet been formulated, but will be an eventual output of PASHMINA.

Future agenda

The 'Future agenda' programme, sponsored by Vodafone Group, is a foresight project with global reach that drew upon expert input from over 140 countries in an exercise designed to identify and analyse the critical themes of the next 10 years. Some implications of the programme for the EU were presented at the seminar by its Director, Tim Jones. An inevitable assumption of any FLA is that there are certainties and uncertainties, although sometimes this is not made explicit. The 'Future agenda' assumes four macro-scale certainties for the next decade, around which other changes will take place. The certainties are:

- a continued imbalance in population growth: by 2020 there will be 750 million more people; more people will live in cities; in advanced countries the population will age and, where there are more children, they will largely be in countries least able to support them;
- more key resource constraints: there will be economic, physical and political shortages of key materials that will cause radical changes in outlook; countries will no longer be concerned just about energy security but also about resource security including land, food, water and metals; resources will not physically run out, but the perception of 'peak' resources will drive political and commercial behaviour;
- an accelerating eastward shift of economic power to Asia: over the past 10 years, Asia has accounted for half the world's GDP growth and this looks likely to continue; at the end of 2008, Asia's GDP was roughly the same as the United States and it is likely to go on growing faster than Europe and the United States in the near future;
- pervasive global connectivity: everything that can benefit from a network connection will have one; the Internet is one of the transformational technologies of the 20th century as is the mobile phone; these two platforms have come together and are creating still more opportunities for transformation; global connectivity will redesign society.

On the basis of discussions in 50 workshops in 25 locations across the world, key insights were developed into how the world is likely to change over the next decade. They were grouped into six clusters: health, wealth, happiness, mobility, security and locality. Each change is variously linked to some others and these interactions can be explored on the project website ([26]). Interpreting these insights through an EU 'lens', Tim Jones proposed a set of insights/challenges of special relevance to the EU.

- Avoiding a diabetes epidemic: With diabetes consuming 5 % of GDP a combination of fat taxation, patient data mining and personal budgets will play a role in stabilising the obesity epidemic, but how can Europe take a lead in 'stick and carrot' innovation that changes behaviour and uses new technologies to reduce consumption and calorific intake globally?
- Active elderly: A wealthier, healthier older generation will increasingly engage in more active lives, have extended careers and become more politically involved.
- Increasing productivity: How can Europe double productivity in the next 20 years, but without increasing resource consumption? As information is

(26) http://www.futureagenda.org

shared globally and insight is commoditised, the best returns will go to those who can produce non-standard, differentiated knowledge.

- With more free agents and outsourcing, non-core functions within organisations are interchangeable and easily rebuilt around value-creating units; within 10 years, around half of the Western workforce is expected to be self-employed, increasingly working on a project-by-project basis.
- Creating value without intellectual property (IP): In a fully-flattened world without IP, how will Europe collaborate to create know-how that others will pay for?
- Using less energy: In Europe consumers are incentivised to use significantly less energy as escalating growth in carbon emissions force utilities to change their business models, but how can we help India and China to level out demand at less than100 GJ/capita and reduce our consumption to match?
- Solar energy: Increasing governmental focus on energy security and climate change drives the uptake of large-scale solar as the leading renewable supply.

This set of issues reflects in broad outline the ideas about grand challenges circulating in Europe, but the project lends a new gloss and a novel understanding of the same concerns. The main item that perhaps has not percolated mainstream thinking is the notion of creating value without IP. The European RDI community is still strongly attached to intellectual property rights (IPRs) perhaps because it has been less successful than others in media and software where open source has begun to make a serious impact.

IKNOW

Today's societal developments are often influenced by improbable events with high impact. These events may be preceded by 'weak signals' that may only be partially recognised by policymakers. It is vital to examine these signals because some of the events are likely to happen, even if we cannot say what these will be. The project IKNOW, introduced by Raphael Popper from Manchester University, aims to provide a sustained and multi-method effort to explore approaches to the conceptualisation of wild cards and weak signals that can inform practice, establish appropriate analytical tools and validate these in specific applications.

Such a system requires arrangements to:

- support the identification, evaluation and exploitation of knowledge related to complex and highly uncertain issues (e.g. wild cards and weak signals);

- interconnect the European and global research, innovation, foresight and horizon-scanning communities.

The top 10 priority issues detected by IKNOW to the date of the seminar are summarised in Table 4. The first five are analysed in more detail below.

Table 4: Policy area and nature of top 10 priority issues

SSH	Cyber crusade: massive e-sabotage by 'hacktivists'
SSH	Soft 'EuroLanding' or 'happy end' in EuroLand
ICT	Secure and safe Internet that is easy to use
Environment	Carbon crunch and the climate bubble
ICT	Information crisis caused by personalised information delivery
ICT-Nano	Nano-lab inside your body
ICT	3D media trustworthily copying reality
ICT	iBrain versus Brain Point
Security	Israel and Palestine join the EU
Health	End of ageing

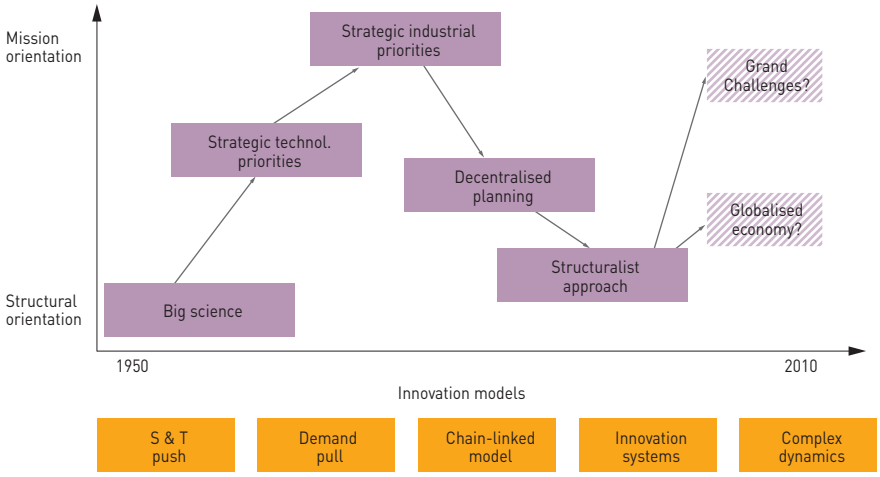
- Cyber crusade: Massive e-sabotage by 'hacktivists': With the aim to achieve social/economic justice in Europe (instead of fraud or geopolitical rivalry), underemployed and politically driven 'hacktivists' target EU agencies, governments and businesses, with cyberattacks and other electronic sabotage.
- Soft 'EuroLanding' or 'happy end' in EuroLand: The growth of debts, austerity packages and spending cuts in Europe lead to critical economic instability and the abrupt transformation of the euro area. A few countries leave the euro at huge political price while others enjoy the new 'Euro Deal'.
- Secure and safe Internet that is easy to use: A new Internet would be developed that would be safe from criminal activity and social pathologies, and it would be very much simplified in use.
- Carbon crunch and the climate bubble: Global carbon markets and pricing mechanisms fulfil the wildest aspirations of the global community. But they quickly lead to runaway speculation and an inflationary carbon bubble, driven by expectations of easy money in carbon finance.
- Information crisis caused by personalised information delivery: Smart Internet media enable targeted supply of information to individual users. This may be easily misused to isolate the user in a virtual world of incomplete or false information.

EUROPEAN FORESIGHT PLATFORM

The past few years have seen a radical shift of emphasis in innovation policy; it is evident in major documents such as 'Europe 2020' and the paper on the 'Innovation Union', but it can be traced back much earlier through formal statements such as the Lund Declaration [27] and the Council meeting of December 2008; in intellectual terms it has a still earlier history. It is the shift from a technology-driven mission to societally driven missions as described in the Lund Declaration that set out quite clearly that 'the global community is facing grand challenges' that required the best analysis, powerful actions and increased resources to find sustainable solutions. The declaration identified specific areas such as global warming, tightening supplies of energy, water and food, ageing societies, public health, pandemics and security.

Matthias Weber from AIT that coordinates the European Foresight Platform explored some of the implications for FLAs of this strategic shift. He reviewed the shifting emphasis of research and innovation policy since the 1950s and the oscillation between more or less structural or mission-oriented models as shown in Figure 12.

Figure 12: Innovation models and policy approaches



(27) Lund Declaration, July 2009.

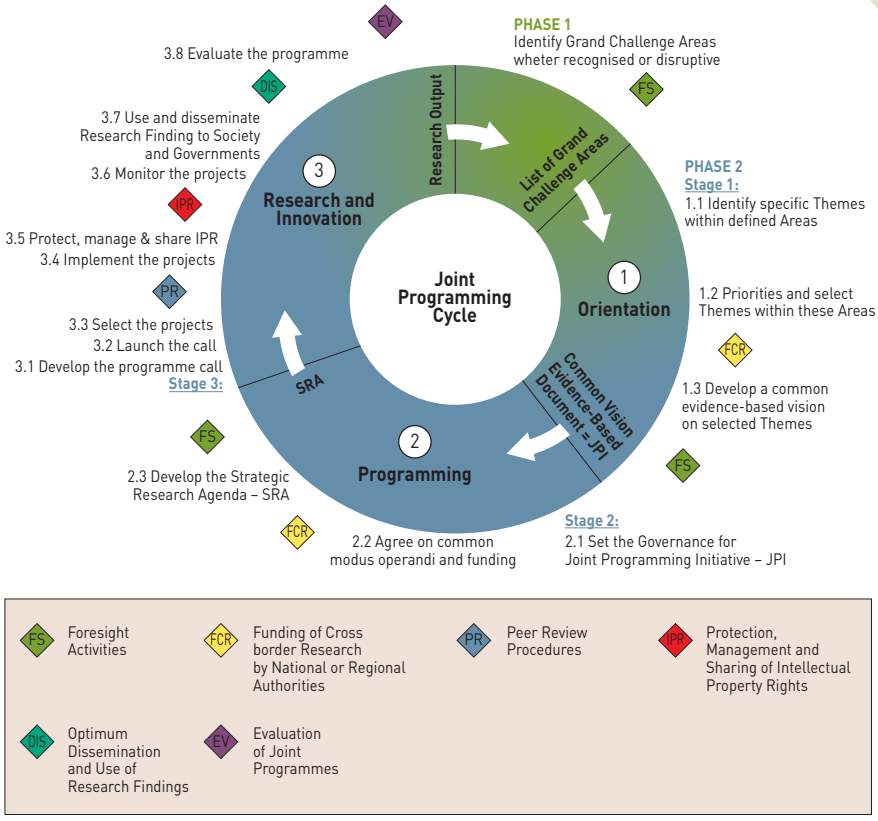
These mission-oriented policies require a strategic approach to research and innovation, building on anticipation of major emerging challenges to society, continuous monitoring, learning and adaptation to respond to fast and sometimes unexpected changes, a mix of demand- and supply-side policy instruments and horizontal, multi-level, vertical and multi-stakeholder policy coordination. In this new policy context of tackling grand challenges, FLA acquires a major significance.

For FLAs to be effective in this new paradigm, they must be tied to the new type of policy cycle. The main requirements are: that they are harmonised with much longer time horizons; they operate as a revolving process with several iterations, as a revolving process, and they operate at different levels. In the joint programming cycle described by the European Science Foundation (ESF), three places are identified where FLAs should operate ([28]):

- identification and selection of grand challenge themes;
- development of a vision;
- definition of a strategic research agenda.

(28) See, for example, 'Developing voluntary guidelines on framework conditions for joint programming in research' (http://www.era.gv.at/attach/FCGuidelinesConsolidatedDraft28_06_2010.doc), from where the figure has been sourced.

Figure 13: Joint programming cycle



The functions of FLA in the new scheme, exercised at various levels, are numerous. They include:

- exploring future horizons and challenges, which is an essential input into level 1 priority setting; examples include the projects SESTI, iKNOW, INFU, 'The world in 2025';
- providing orientation and guidance once grand challenges have been identified; an example is CIVISTI, but the field is still under-developed;
- exploring and checking alternative futures using scenarios and models while keeping alternative futures in mind; AUGUR is an example;
- defining strategies, setting priorities; roadmapping is the prevailing approach, but a more adaptive and flexible approach is needed; an example is ESRIF/ForeSec;

- identifying and assessing policy options; an example is Europe INNOVA Sectoral Innovation Foresight;
- supporting coordinated action; grand challenges require horizontal, vertical, multi-level and multi-stakeholder coordination as foreseen in the European innovation partnerships; an example is FARHORIZON.

Matthias Weber drew conclusions as to how FLAs need to improve to provide better support to mission-oriented RDI policy based around grand challenges.

- FLAs should be developed to provide a better foundation for selection of grand challenges at level 1 of the joint programming cycle. This would require: strengthening the exploratory, horizon-scanning functions and creating a knowledge platform to underpin transparent selection processes.
- FLAs need to incorporate more adaptive thinking in priority setting. Grand challenges will require very long-term programmes and conditions will change; it will require always keeping alternatives in mind and adapting when needed.
- FLAs should be complemented with arguments about rationales for policy intervention; dealing with grand challenges will imply rethinking the role of policy and the legitimate basis for policy intervention. Such thinking should be reflected in the practice of FLAs.
- FLAs can have a powerful coordinating function and this needs to be better exploited. Grand challenges require mobilising many different actors and stakeholders in a coherent way and FLAs can contribute to this process.

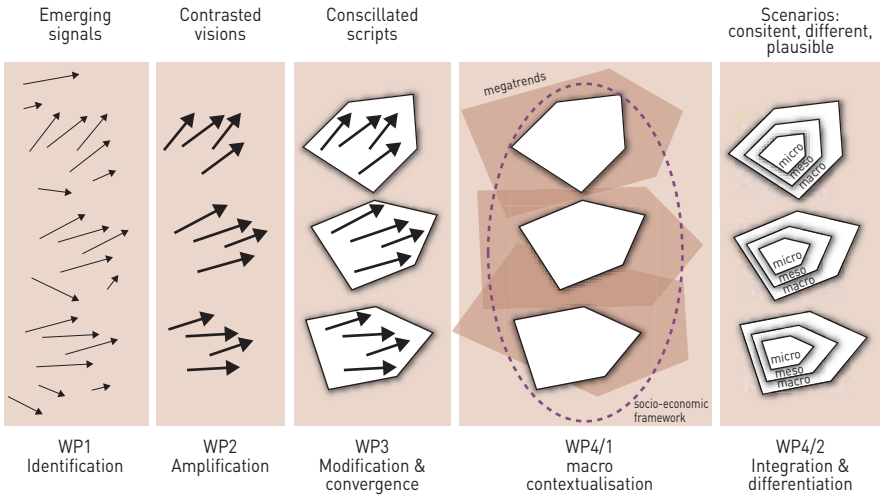
INFU

New innovation patterns such as open innovation, user innovation or soft innovation are challenging established ways of developing innovations. It can be expected that some of these concepts and models will become widely diffused in the future while at the same time totally new innovation patterns may emerge. There has been little exploration of new innovation models and visions and their implications for the innovation landscape, economy and society. A better understanding of plausible long-term scenarios for changing innovation processes and configurations and their implications for society and economy can help practitioners and policymakers in developing specific strategies to exploit the full potential of new innovation patterns. This is the starting point of the 'Innovation-Futures' (INFU) project introduced by Karl-Heinz Leitner. The concept of new innovation patterns not only encompasses novel emerging concepts, ideas and strategies for how innovation is organised, but also includes the generalisation of well-known trends, which are important in spe-

cific industries or areas, but which conceivably may have a larger impact or potential for other areas in the future.

INFU approaches these questions by a foresight process that combines weak signal scanning, scenario development and scenario assessment. The essential dynamic of the process is to move from a multitude of weak signals about novel innovation mechanisms, through 'contracted visions' and 'consolidate scripts', to a few consistent and plausible scenarios. The process is captured in Figure 14.

Figure 14: From signals to scenarios



The weak signals of innovation patterns which are already apparent and visible, but have not yet reached the mainstream, are identified from review of the academic innovation literature and by scanning the Internet, newspapers and magazines. Based on this collection of weak signals INFU has generated visions of how innovation processes may develop in the future. To do this the weak signals are clustered, selected and integrated by 'amplification'. The principles underlying amplification are that ideas may be:

- transferred to other sectors, to other user groups (e.g. from fashion to the furniture industry; elderly people instead of children or vice-versa);
- generalised as a mainstream practice (e.g. if active users' involvement in innovation processes became the default); or
- radicalised (e.g. user involvement in innovation process develops into an innovation actively developed by the demand).

Through this amplification, a set of 19 visions of how innovation might evolve were collated and then clustered and selected in discussion with expert groups to produce a final set of 'nodes of change' summarised in Table 5 below.

Table 5: Nodes of change

Open source innocamp society	Innovation camps where people gather for specific innovation tasks for a certain time are becoming increasingly popular. Often the idea is linked to the open source society where a number of products and services are developed in close interaction among users. Is the required infrastructure based on an open source paradigm? What are the dangers and limitations?
Widespread creativity	Innovation is becoming mandatory for more and more people in companies and other types of organisations. How can we avoid 'innovation overload' and 'innovation divide'? What does it mean to live in an environment that is constantly innovating?
Waste-based innovation	The establishment of innovation patterns that are fully consistent with a circular flow of resources was unanimously assessed as a top priority in the INFU experts' dialogue. How can novelties emerge out of used products? What kind of consumer types are associated with the pattern?
Automatised innovation	A number of new techniques such as semantic web analysis allow for automatising parts of the innovation process from idea generation via implications for design and testing. What are the economic and social consequences?
City-driven system innovation	Cities are increasingly expected to play a major role as innovation drivers. In particular, systemic sustainability innovations may best be implemented at a city level. What are adequate mechanisms for cities to reap the benefits of this potential?
Deliberative innovation	It seems widely expected that citizens will play a more important role both in governing and implementing innovation activities. How will the new type of 'deliberative innovation' be governed? What will be the outcomes?
Innovation chain integration	Innovation is expected to become globally dispersed. But what will be the mechanisms to integrate all the distributed and diverse elements and to match ideas and solutions with problems and needs?
Social experimentation	Social innovation is more and more recognised as highly relevant for developing innovative solutions addressing societal challenges. New modes of innovation are required to align social and technological innovation activities. Participatory experimentation will play a key role but what are the right instruments and levels required for successful solutions?

Several visions incorporate fundamental changes in the mechanisms mediating between the demand for innovation and the supply. In most cases, the role of companies as dominant broker between needs and solutions is shrinking in favour of individual or (more often) collective users of innovation. A wide variety of hybrid value creation business models is being proposed. Most visions emphasise the need to address societal challenges and especially environmental issues as a key driver of change not only for the target of innovation but also for innovation patterns. Some visions describe fundamental changes in the macroeconomic environment such as 'economy of contributions', 'on-demand economy', 'surplus ecosystem' and 'learning-intensive economy'.

CIVISTI

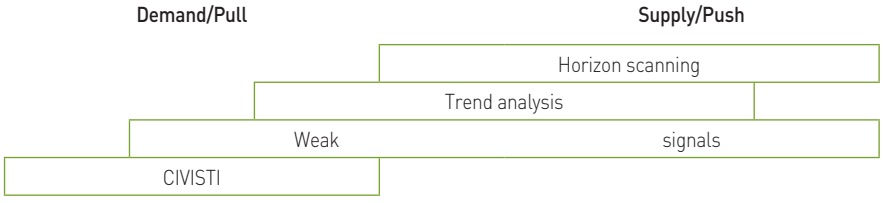
If research is to be directed to societal challenges then there is a strong logic to consulting the citizens that comprise society as to what those concerns might be. CIVISTI is a project that has tried to find efficient and effective facilitating methods to collect these concerns and expectations and to transform them into relevant research agendas. The project was introduced by Lars Klüver of the Danish Board of Technology that coordinated the project.

CIVISTI is a research project of FP7 under the call for 'Blue sky research on emerging issues affecting European S & T'. It gave citizens from seven EU Member States an opportunity to define their visions of the future and offered the means to transform these visions into relevant long-term STI issues. This novel process of citizen participation, supported by analytical capacity of experts/stakeholders, was intended to produce a list of new and emerging issues for EU S & T and policy options of relevance to future framework programmes.

The need to develop working methods of facilitating citizen participation in research choices is founded in several factors. FLA is extremely sensitive to context; the formulation of the process has a big impact on the outcome and therefore it matters who defines the content and the priorities. If the eventual beneficiaries are supposed to be the citizens then they should be involved from the early stages. From another perspective, liberal democracies need political balance and legitimacy when creating strategy; there are many organised interests that do not have agendas that entirely match those of citizens, but that exercise influence on state decisions (lobbycracy) and this calls for some compensating mechanism.

Citizens increase the value of forward-looking activities in many ways; they are the present carriers of the history and diversity of Europe; they represent a wide knowledge and value base; they are 'experts' on everyday living and their expectations of what constitutes a good life; there is a democratic legitimacy to define relevant futures; they are independent in the main of organised interests and their participation increases the chance of socially robust policy options. The emphasis on citizen participation places CIVISTI firmly on the demand-pull side of FLA methodologies as indicated in Figure 15.

Figure 15: CIVISTI compared with other forward-looking approaches



The methodology employed in CIVISTI comprised three steps. First, citizens around Europe were asked about their visions for the future. Second, experts and stakeholders analysed the visions and transformed them into research agendas and policy options for European research. Third, the results were given back to the citizens to validate and prioritise. Citizens produced 69 visions for the future of Europe in the first step of the process; these visions were holistic, multi-thematic and interdisciplinary and were spread across multiple domains of society. Experts had the challenging task to 'translate' these visions into S & T issues and policy options and into concrete recommendations for EU research policy. The group of experts and stakeholders produced a list of 30 recommendations for future European S & T and research policy also with much diversity. Many of the recommendations relate to today's grand challenges: ageing society; sustainable energy production and transport; environment and climate; supply and quality of water and food. As the third step of the CIVISTI process, the citizens were asked to prioritise the recommendations made by experts and stakeholders. That resulted in the top 10 list shown in Table 6.

Table 6: Top 10 recommendations

Recommendation	FPs?	Implementation
Dignity when dying	-/0	SSH: Humanistic research
Tools for disabled	+	SIS MMLAP: Participatory research
Decentralized energy	++	Energy/SSH: System & conflicts
Dense eco-cities	+	Environment/MMLAP!
Direct democracy & eVoting	0	ICT:TA – credibility of solutions
Social innovation for ageing society	--	SSH: Topic – participation research
Attractive public transport	++	Sustain research. MMLAP topic
Plants for extreme weather	+	FAFB work programme
Re-appropriate countryside	--	SSH topic
Urban multigeneration lifestyle	--	SSh & ICT topic

The second column indicates the level of attention that the topic has previously enjoyed in the framework programme, with ++ meaning it has been well addressed and -- meaning it has been neglected. The third column indicates in which context the topic might best be followed up.

There are interesting lessons to be drawn from CIVISTI. Participatory FLAs can signal important changes and they provide a baseline for STI social accountability. CIVISTI in particular has revealed a new horizon to scan — that of

challenges as seen by the citizen. Citizens don't 'expect' innovation futures; they want them to be developed according to ideas about 'the good life' — an attitude that contrasts with the traditional consumer/user-driven commodity focus.

Break-out groups

Break-out groups were constituted; their reports have been pooled and items clustered under the following headings: gaps, methods and implementation.

Gaps

The diversity of Europe means that the grand challenges and their intensity differ across the Member States; for example, the stresses of unemployment vary considerably across the Union and this consideration may not be fully recognised in present studies.

The huge financial burden of maintaining proper infrastructure is insufficiently recognised. This fact has been pointed out by the World Economic Forum and the 'underinvestment in infrastructures' is recognised as a major risk ([29]).

Securing an industrial base for the future and preserving competitiveness, high value added and resilience is a societal challenge ([30]). But the present degree of competitive pressures from emerging economies may be considered to be a distortion and a 'market failure' that might not persist. Other mitigating (or self-limiting) factors have been overlooked in the analysis, such as the domestic constraints to growth in China that may invalidate some projections. Better understanding is needed of where and how wealth is created.

The influence of technology on societal changes needs to be better understood. FLA methodologies address opportunities as drivers of innovation, but risks and resilience aspects need innovations as well. There is a lack of sufficient work on demand and the relationship between consumers and innovation. There is a need to address the different roles (positive or negative) of standards on different sectors.

(29) World Economic Forum, *Global Risk Report 2010* (http://www.swissre.com/pws/about %20us/knowledge_expertise/top %20topics/other_topics/globalrisks/grr2010.html).

(30) This challenge is addressed, for example, in the 'SafeFuture' initiative prepared by the European Technology Platform on Industrial Safety (http://www.industrialsafety-tp.org).

Methods

The relationship between policy implementation and foresight analysis should be continuously re-examined.

New coalitions of actors are needed for innovation; societal challenges should be the boundary conditions for the industry to develop new technologies/products but may not be the sole driver; the market will remain the final judge. New market opportunity can be expected to emerge from such societal challenges.

It is necessary to avoid *ceteris paribus* thinking; in the real world the relationship between everything is almost always changing. Demonstration of the resilience and sustainability of solutions needs to be more convincing. The borders of disciplines, technologies and industrial clusters is disappearing, but analysis is still often based on old silos.

Implementation

R & D and innovation policies should factor externalities into analysis as a principal mechanism to drive technology choices and industrial development agendas. Thought is needed as to how to choose the level at which consumer behaviour can best be influenced. Mechanisms are needed to lower entry barriers to promising solutions and to create level playing fields for new options such as renewable heating and cooling systems, and electric vehicles. Smart and sustainable cities must be devised and ways of life adapted to them.

A trade-off exists between policy mechanisms to achieve solidarity through transfers of resources and measures designed to promote mobility, where people and activities move to compensate for imbalances.

Known technologies are often not applied because of a lack of funding to develop and deliver a product; they may also fail as a consequence of a lack of social acceptance (education, culture, economic reasons). It is necessary to pay more attention to leverage of the market side (user-consumer education) and not only to focus on the supply of technology and R & D.

The link between RDI and policy may encounter conflicts of interest; the transparency of industries and research universities cannot be guaranteed. The role of the regulator and functions between policy and application need to be included in questions of implementation.

Funding of research should be based on a bottom-up approach involving consultation of stakeholders and should not rule out potential new technologies or great challenges.

There must be a balance between blue sky research and applied research. Knowledge is poorly interconnected and future programmes should have vertical components focused around the grand challenges, but also there should be horizontal components identifying cross-cutting issues and the sharing of technologies across the vertical elements.

Paraskevas Caracostas – EC, DG Research and Innovation

Jean-Claude Burgelman – EC, DG Research and Innovation

Robert Burmanjer, Domenico Rossetti, Perla Srour-Gandon – EC, DG Research and Innovation

Conclusions

The main purpose of the seminar was to determine how European and national forward-looking activities could inform the impact assessment of the upcoming EU research and innovation policies and programmes. The conclusions of the seminar are therefore assembled under headings relevant to the impact assessment.

What are the policy objectives?

The FLAs endorsed the essential diagnosis of the 'Innovation Union' and the overall objectives of future RDI policy to address directly the main societal challenges facing Europe over the next few decades. The FLAs draw especial attention to the role of the EU in a rapidly changing world (globalisation, Asia development, ageing population, mega-cities) needed continual reassessment. They concur with the fundamental importance of resource constraints (raw materials, energy) and the green paradigm shift. They confirm that new indicators of social success are needed ('Beyond GDP', healthy life, happiness). It is comforting that the exhaustive analysis constituted by the sum of work that has been made in many places with different approaches confirms the validity of the overall objectives of the 'Innovation Union'.

Specific objectives for future research that emerged from a rich and animated discussion with stakeholders include the following.

- Understand better the relationship between man and technical change. Technology and society evolve together; the products of technology shape individual perceptions and the ability to act. Reflective technological development is required in order to shape this process in a socially desirable way.
- Prioritise sustainable production and consumption. Research into new ways of matching production to social needs in the face of changing basic global conditions while preserving the integrity of the ecosphere will be fundamental. Resource constraints will be strongly binding for the foreseeable future. Adequate infrastructure must be guaranteed for producing wealth while ensuring well-being.
- Support adaptation to a world where innovation will be driven by users. As the RDI begins to focus on societal challenges so the nature of the system changes from a supply-led to a demand-led character. Effective techniques must be found to involve users in decisions and perhaps the focus of innovation itself will move more towards users than conventional suppliers.

- Foster innovative 'ecosystems'. As the model of open, collaborative innovation driven by users takes hold, it will be necessary to recognise the role of innovative 'ecosystems' that will be able to express the social, economic and cultural forces that need to be understood and harnessed and will be able to manage the complexity of innovation outside the laboratory.
- Encourage a new generation of dynamic actors in hybrid technologies. Computer science, telecommunication devices, nanotechnologies and synthetic biology could revolutionise society, help reduce the domination of large institutions in research and innovation out of large institutions, undermine conventional ideas of IPR and open up new opportunities for small, nimble, knowledgeable actors.

What are the policy options?

The policy options discussed are either to continue with a research and development programme based in traditional disciplines whilst strengthening interactions between disciplines deploying all the instruments of the ERA, or to structure the effort directly on major interdisciplinary issues addressing the grand challenges and simultaneously linking RDI policies in operational areas with other policies and instruments of the Union. The weight of presentations and discussion gave preference to the second policy option.

Implementation of this second policy will require building a broad coalition of actors capable of answering to both societal challenges and emerging STI needs. This coalition will need to mobilise FLA researchers and bottom-up (STI) actors whilst simultaneously ensuring the participation of stakeholders, including users and civil society. The European Technology Platforms provide a mechanism for incorporating selected, largely commercial interests, but efficient dialogue with citizens still needs to be strengthened.

Future RDI should focus more on the 'intangibles' (human capital, education, design, branding, etc.) and should define and ensure 'responsible innovation' (corporate social responsibility, sustainability and ethics). The coherence between these activities will also be facilitated by the same broad coalition of actors.

The resilience of policy options needs to be more fully and convincingly assessed. In real life the connections between activities are complex and mutable; better methods to test the stability of the results of FLA are needed. More attention should be also paid to the transitions to scenarios, not only to describing the final outcome.

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(31) http://ec.europa.eu/research/social-sciences/pdf/eu-forward-looking-activities_en.pdf

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More information, including slide presentations, are available on:
http://ec.europa.eu/research/social-sciences/fwl-era-and-innovation_en.html

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This publication presents a synthesis of European and national forward-looking exercises in the fields of science, technology and innovation. It answers to the two following questions: «What recent national forward-looking activities tell us on the future of science and technology?» and «What EU forward-looking activities tell us about societal challenges that need to be addressed by EU research and innovation?». This publication provides a fresh insight on the main current trends and expected perspectives on the European Research Area and Innovation Union including citizens' visions about science and technology.

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