NTW EG – Analysis of Summarised Hearings of Experts
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"The empires of the future are the empires of the mind."

Winston Churchill, September 5th, 1943

Introduction and Contents

A List of six questions were proposed by the Chair and Rapporteur[1] of the High Level Expert Group on "Foresighting the new Technology Wave – Converging Technologies". These questions were designed to establish the major trends as a result of the developing converging technologies policies which were perceived to be in place

Questions

The six questions were as follows:

Q1) What do you consider the most beneficial, and what the most troubling development to come out of convergent technologies within the next 10 years?

Q2) Consider research on convergence in your own country or your own field in respect to national, global (US), and specifically European trends:

- Do you find that that research would pretty much look alike anywhere or does it have a regional, national or European flavor?
- How does the national research position itself in regard to similar research in the US or Europe - by way of cooperation or competition?

Q3) Our expert group is premised on the idea that (groups in) society might accommodate convergent technologies more easily if the European research agenda is properly focused and defined.

- Do you believe that this can be done?
- What kind of research focus or definition might do the job?

Q4) What perceptions of threat and opportunity will serve as incentives and barriers to the dissemination of convergent technologies in Europe?

Q5) Who are already or in the very near future the winners and losers of this rush toward convergent technologies, and how should we take them into account?

Q6) The risks associated with convergent technologies are unknown even to the point that often one does not know whether there are any risks involved and what they might be. How can we handle or address such unknown risks?

[1] Prof K Bruland, Univ of Oslo, and Prof A Nordmann, Univ of Darmstadt

Analytical responses by Question

Q1 - Benefits or otherwise

Q1) What do you consider the most beneficial, and what the most troubling development to come out of convergent technologies within the next 10 years?

Nearly 50 commentaries were analysed under this heading, in three categories:

Common
3X[2] - Developments can go either way in the next decade, depend son us!
2X – The environment for CT is critical to positive of negative outcomes, and if only used to re-invent the wheel, not very useful
2X – Media bias can heavily influence perceptions of outcomes.

Beneficial	**Troubling**
6X Generic useful technology with major impacts	7X Ethics are not yet sufficient for understanding implications
5X Science will benefit from new understanding	6X Speed of development is high
4X Sustainability will be supported by new research	4X Chance of mis-use increase with pressures and speed
4X Health applications will lead in European research	3X Prioritisation is difficult and some mistakes will be made
2X Communications will be seamless and marginal cost	3X Long Term human impacts are not well understood (yet)
2X Spillovers will be high to other sectors of the economy and technology sectors	2X Regulations are not advanced enough to cope
1X Emergence of Vision/Tech Guru helps adoption and understanding	1X Remediation of impacts preferred over prevention
Score 24	**Score 26**

It seems experts see almost a balance of benefits and possible problem areas:

Q2 - Structure of NTW Research

Q2) Consider research on convergence in your own country or your own field in respect to national, global (US), and specifically European trends:

- Do you find that that research would pretty much look alike anywhere or does it have a regional, national or European flavor?
- How does the national research position itself in regard to similar research in the US or Europe - by way of cooperation or competition?

[2] nX is the number of times a comment was made in this category, based on editing and analysis of replies.

Responses analysed as Similarities – specificities of national system; National vs European or US system, and common issues.

Common Issues across NTW R&D systems	National Similarities of Systems	National vs EU and/or US Systems
3X Risk taking necessary	4X Diversity is benefit at this level	4X Global approaches strong, often permits weak local base
3X CT is self organizing, global	3X Bottom up approaches favour national systems	3X Critical size needs big view
2X Needs much basic research to be done	3X Academic basis suits national system	2X Multi-disciplinary needs wide scope of skills
1X Speed and width of work needed is new	3X Approach necessary to survive in new age	2X Competition beneficial to rate/quality of progress
1X Asia is great unknown actor	3X Specific regulation and commercialisation suited to national systems	1X Spin-offs important for all levels
1X Differences are not due to culture!	1X Cooperative model easiest at national level	1X Suitable level as EU framework is converging

Q3 - Society Driven?

Q3) Our expert group is premised on the idea that (groups in) society might accomodate convergent technologies more easily if the European research agenda is properly focused and defined.

- Do you believe that this can be done? Is it possible?
- What kind of research focus or definition might do the job, How could it be done?

Is it Possible to have a Society driven R&D Agenda?	How could it be done?
3X Societal involvement improved	5X Better Monitoring
2X Science is not mainstream enough	5X Better governance
2X Not the only nor key issue	4X Take systemic approach to policy
2X Robust agenda (i.e. redundancy) needed	4X Needs visionary and mission approach
1X Diversity of research important	3X Co-operation model essential, Civil…
1X Social Sciences weak, they are key	3X Appropriate Centres
11 Comments made	2X Enlightened directed funding

It seems there are more ideas about how to develop a societal driven agenda than concepts as to its feasibility – is it assumed then?

Q4 - European Strengths and Weakness

Q4) What perceptions of threat and opportunity will serve as incentives and barriers to the dissemination of convergent technologies in Europe?

European Strengths	European Weakness
3X Cooperative model advantageous	2X Transformational impact unknown
2X Social Cohesion important	2X Rigid institutions
2X Cultural « Width » useful	2X National regulatory barriers
1X Integration movement in EU	1X Cultural upshift but unclear market
1X Consumer consciousness	1X IPR model - impractical currently
1X Flexibility	1X EU RTD inefficiencies
1X European vision	1X Language barriers
1X Life Sciences drivers strong in Europe	1X needed to lift weak economy
1X Education base solid	1X lack of economic savvy in R&D Staff
	1X insufficient public investment in RTD
	1X insufficient investment in private RTD
	1X lac kf entrepreneurial scientists
13 responses, 8 factors	**15 responses,12 factors**

It seems European weaknesses are wider spread than the strngths, and more numerous. However, one can argue if education and healthcare are strengths or weaknesses, but in the sense of EU having an advanced system that delivers quality to a high percentage of the population on a social cost model it is a strength.

Q5 - Winners and Losers

Q5) Who are already or in the very near future the winners and losers of this rush toward convergent technologies, and how should we take them into account?

Common Issues	Winners	Losers
2X Nano divide divisive	2X Systems with high absorbtive capacity	3X the over governed, will get rolled over
2X Risk analysis	2X Larger MNCs	3X Over-governed as a system
2X Techliterocrcay	1x Richer peoples	2.5X Europe as a whole
1X academia – industry – social dialogue	1x Richer Countries	2X Systems with low absorbtive capacity
1X Asia as an unknown	Publications: S Korea, PRC, Poland, Spain and Israel	2X Humanity and its future development
1X Social Sciences	Patents: US, Germany, Japan, France, UK	Over specialised countries, until US clear ways for new purchase.
1X China as an unknown	Harmonious Activity[3], Isr, B, Aut, Russia, Japan, F, Sw, Australia, NL, IT	Developing Nations Summitt
(1X Unified China as unknown)	Overall – US, China, India	Small business
Consumer acceptance	Well governed Int. Orgs	Those below critical mass
	Excess critical HRD mass	US long term (demographic shift heading Hispanic,

[3] Harmonious Activity is one where the ranking between academic papers and technology patents is less than ½ of the length of the ranked list; i.e. no more than 10 rankings different in this case

		survey)
	Merger and Acquisition models	IT and technicians turning too specialized too early
	Those who can manage complexity	
	Players used to living on the edge	
	IT and Technology adopters	
	Users and adapters of technology	
	Benefit of technology capturers	
Totals	**20 commentaries on 19 factors**	**19 commentaries on 14 factors**

Q6 – Risk management

Q6) The risks associated with convergent technologies are unknown even to the point that often one does not know whether there are any risks involved and what they might be. How can we handle or address such unknown risks?

The responses to this question was quite well clustered:

Factor	**Frequency**
Risk Assessment	6
Risk Monitoring	5
Precautionary Principle	5
Develop risk culture	3
Doomesday effect can take hold	3
Tech penetration critical	3
Risk management	3
NGO's and risk	2
Institutionalise Risk Aspects	2
IPR	1

So about 30 commentaries in just 9 factors. The implementation and use of some form of risk assessment is a key component of all commentary.

Consolidated Responses

1. Pluses and Minus

Q1) What do you consider the most beneficial, and what the most troubling development to come out of convergent technologies within the next 10 years?

Common Issues

Can go either way…
Most of the things about CT are both troubling and beneficial, it depends on how we use them, that is a critical issue. (R-6)

Intrinsically, as much in science as in technology, they are fairly neutral - but it is how to use them that counts. (R-6)

How do we even think of "life" as an entitiy in the future - what would that means to our life narrative (R-6)

Environment:
Each (technology) promise dramatic leaps, and, in combination, have the power to reshape our lives, but this means that European cultural, ethical, socio-economic approaches are destined to change at least partially. (R-10)

If people and society are able to accept them it is possible to send them ahead in a fast way, otherwise they become the future of other people. (R-10)

Media Bias
The technology itself allows both for beneficial and for troubling developments. Science fiction as well as the glossy investment brochures of start-ups have shown both extremes. (R-5)

Most people have no idea of what NNT is and when it comes of age, it runs the risk of being already biased in public psyche, due to media coverage of "Grey Goo" type of comments (R-7)

A: Beneficial

5X Generic useful technology with major impacts
One of the fundamental features of convergence, i.e. that knowledge and tools in one area will spill over to the others, has created the dynamic of accelerating paces of discovery. (R-2)

It should be noted that convergence of disciplines is not the only form of overlap. We may expect to see consilience as well. This occurs when common links occur between parts of

theories within disciplines. As the linkages get longer, we will get more all-encompassing theories will apply to larger systems. (R-2)

The exact nature of the CTs is still to be determined in relation to their relative importance and eventual pervasiveness (R-3)

CTs becoming highly pervasive, such as the presentation of a vast array of business opportunities (R-3)

Great new technology able to exploit a global, free-trading system (R-7)

5X Science will benefit from new understanding
Atomic-scale work in the field of semiconductors (scanning tunneling microscope) benefits research into nano-structures. This is shown in the now familiar convergence graphic to the right. (R-2)

Many as yet unanswered questions in the areas of physics, chemistry, medicine, neurology, ecology will be understood. New phenomena, as yet unknown will likely become part of the body of knowledge. (R-2)

Science itself will be the first beneficiary. (R-2)

Instead of having developments in one field forming the basis of new work in the same field, it is leading to a mesh of knowledge in which work in the mathematics of abstract algebra become relevant to the transfer of genetic information. (R-2)

In the short term, any mix of the convergence should lead to the development of equipment, methodologies/techniques and instrumentation for the manipulation of organic and non-organic matter in a manner that has the potential to alter the relationship between humans and physical matter across the whole range of material we use. (R-11)

3X Sustainability will be supported by new research
Bio-materials could enable substitution of fossil fuel for materials (R-9)

Energy - The contribution of nanoscience and nanotechnology to fuel cells (R-9)

Converging technologies founded on nanotechnology are without doubt an incredible opportunity for academia and industry. The width of application is too broad to say where the maximum benefits will lie, the better use of scarce resources though is a clear winner and the economies of scale mean we will use much less to do the same things we are doing to-day (R-12)

3X Health applications will lead in European research
Disease - The possible prevention or cure of genetically related diseases (R-9)

Health care, the highest level of technological development will occur once there is full understanding of gene variations with reference to environmental factors such as lifestyles, foods, work conditions, family interactions, pets, etc., that is, fundamental understanding of

the principles underlying cell differentiation to include a full understanding of how differences in characterization (R-11)

Understanding the neural architectures and algorithms actually employed by the human brain could perhaps then lead to a rational or planned approach to preventive health care and disease/illness treatment (R-11)

2X Communications will be seamless and marginal cost
Removal of barriers to 'communication' caused by physical barriers (R-9)

I think the most compelling and the most beneficial is the convergence of technology is our **unprecedented access to information** which means that we all have to store nothing in our own heads but absolutely having to bear in mind that there is a difference between information and knowledge. (R-6)

2X Spill-overs will be high to other sectors of the economy and technology sectors
Industrialization should be characterized by the introduction of relatively small number of broadly similar production processes to a large number of industries. (R-11)

Likely the most beneficial outcome in the near to medium-term will be the continuing development of instruments for observing and measuring phenomena at the nano-scale. (R-2)

1X Emergence of Vision/Tech Guru helps adoption and understanding
Emergence of "visionary-type" opinion leaders, endowed by a broad spectrum of diverse cultural roots. (R-1)

B: Troubling

6X Ethics are not yet sufficient for understanding implications
There are many profoundly ethical considerations to be undertaken. (R-2)

We may not have the capacity to address the ethics even if we wanted to. Many ethical issues presented by modern technology have no historical precedent. The ability to create or extend life is new. (R-2)

The ability to dramatically alter the environment poses whole new questions of right or wrong. (R-2)

To a large extent, our moral sense is drawn from a cultural history that necessarily spans centuries, if not millennia. That is how long it takes to develop a shared concept of value. Technology does not allow for that kind of long time frame. (R-2)

Limits to our (societal) competence primarily are technical (the belief that) (R-9)

Widespread use of genetic modification within the bio field (R-9)

5X Speed of development is high
Technological capability is far outpacing our ability to assess impacts, or to make the right kind of choices. (R-2)

Over-looked important systemic aspects of changing scale, and consequently focus far too much on the implications of decreasing size at the nano-level. (R-11)

If self assembly will ever happen, then no-doubt it can be a difficult decision to make once certain levels of bootstrapping have been mastered. If we are fast enough to reach for the off switch who knows, probably the answer is no. (R-12)

Public opposition and lack of skills pose serious threats to the development of the CTs (R-3)

Long gestation period of revolutionary new technologies are a problem (R-3)

Requirement for numerous complementary innovations make progress complex. (R-3)

4X Chance of misuse increase with pressures and speed
Potential for misuse of the technology, as had been done with other technologies in recent times (R-7)

An uninformed laissez-faire, where the technology could develop just any direction and civil society is confronted with the consequences (R-5)

Development of new institutional arrangements on disclosing novel challenges, unforeseen effects and how to manage or govern "potentially" dangerous science. (R-11)

How do we ensure research resides in the hands of those who would apply the science for beneficial purposes rather than for maleficent purposes. this duality has to be addressed (R-11)

3X Prioritisation is difficult and some mistakes will be made
Difficulties in reaching a consensus on the priorities (R-1)

Allocation of huge amounts of research funding for 'technical fixes' without focus on solving recognised societal problems (R-9)

Prolongation of life priority, rather then on securing a good life within the 'normal life span'(R-9)

3X Long Term human impacts are not well understood (yet)
In the long term (some decades) our brain could be modified through brain- machine symbiosis (Cyborgs!) (R-10)

Most troubling outcomes are the related societal and individual privacy issues. (R-11)

Have we thought about what Computing we want? If we have pervasive computers now you are living in a world where the computing is ubiquitous and embedded, then clearly it follows

we have to ask ourselves what we're going to need to learn anymore? What you would need to know that makes you different from others – what delineates you from me? (R-6)

2X Regulations are not advanced enough to cope
Practioners saw no need but even regulators agreed that it is probably too early to regulate for H&S, until specific risks are established through research, the H&SE specifically preferring the monitoring approach for the moment. (R-12)

Potential issues of IPR for self assembly systems as a major area of issue (R-7)

1X Remediation of impacts preferred over prevention
Focus on monitoring and remediation of the environment, rather than on prevention at the source (R-9)

2. Structure of NTW Research

Q2) Consider research on convergence in your own country or your own field in respect to national, global (US), and specifically European trends:

Common Issues across NTW R&D systems

Research Council are highly risks averse and far too over-cautious on the type of research they fund. (R-6)

Safety in research is the death knell for research. It's one area where safety first, the precautionary principle – for scientific research at it's best does not apply. (R-6)

Peer review and public sector funding in UK is not doing justice to tax payers money (R-6)

The NBIC research communities looks like self-referring (technological) communities, (R-9)

Doubt that Europe can really orient the development of NBIC technology (and society). (R-10)

Probable that NBIC technology, developed around the world, orients Europe. (R-10)

In a globalised world, local traditional avenues of knowledge are the only possibility to survive without an increasing subordination to strong national(istic) entities. (R-1)

There is a need for much more basic research in all areas (R-7)

A. Similar?

- 2A: Do you find that that research would pretty much look alike anywhere or does it have a regional, national or European flavour?

There is little to suggest that NNT has any unique features that is not shared by other new technologies; but this time – with the rate of increase of lab to market the issues of application and basic research are being discussed simultaneously; and this maybe new (R-7)

In a globalised world, local traditional avenues of knowledge are the only possibility to survive without an increasing subordination to strong national(istic) entities. (R-1)

Yes, thinking here is focusing on commercialization (and other forms of value capture) of research results. Canada has invested substantially in research, has made some impressive contributions, but has fallen short of targets for technology transfer into commercial benefit. (R-2)

Canada has had an R&D policy directed towards funding R&D organizations according to the merit of their work, as assessed within their culture. As a result there has been little interest in producing and selling products.[4] (R-2)

Work is of high academic and scientific excellence, but by ignoring downstream value-capture, research institutions miss out on an important source of self-funding and therefore rely on government support. (R-2)

Technological uncertainties are multifaceted, relating to the soundness of a new technology, determination of technological specifications, and ramping-up issues[5]. (R-3)

Real Nanotechnology to-day – the people that are working on the bottom up approach, and thus converging technology, has a cottage industry flavour, in that sense it is parochial (R-12)

European industry is not yet prepared to consider the convergence aspect on a broader scale. (R-4)

Nanotechnology Research in Canada: With the US most active in scientific nano-science publications, Canada has a regional and global flavour. (R-11)

Most national Research has yet to prepare the basis for a convergence "à la NBIC". (R-4)

The basic principles are the same everywhere. However the specific application areas and the approaches might change regarding the specific needs of an area. The cheaper the methodology, the wider the range of cultural diversity of developments. (R-5)

It is of a more general issue as we see in the globalization debate. Here a fundamentally new perspective or rather approach is needed on how the different actors want to act on a global level. (R-5)

B. Juxtaposition

- 2B: How does the national research position itself in regard to similar research in the US or Europe - by way of cooperation or competition?

Cultural competition is an unavoidable component of the process. However "glocal" cooperation is also unavoidable to exploit limited resources. The critical point is the selection of both "cultural" and "gestional" (i.e., decision-maker) leaders not in terms of nationality but of real capacity to cope with a globalised and rapidly globalising environment.(R-1)

There are a number of specific European qualities that will distinguish our approach from that of other regions in the world. One is the multilingual (and multimodal) form of communication which is rather different from say the US situation (with a single language).

[4] More detailed brief on this concept available later, says author

[5] Rosenberg, N. Uncertainty and technological change. In: Landau, R., Taylor, R. and Wright, G., (Eds.) 1996. *The Mosaic of Economic Growth*. Stanford, CA: Stanford University Press

This requires a special focus on the respective technological challenges, which in future will be a great asset on the international market. (R-4)

The diverse cultural “content” in our societies which needs to be taken seriously and again offers the potential for immense market opportunities (R-4)

America has a much more open perspective and a much more risk friendly attitude than the British do. More recently and what actually superseded working with large corporations, where there are the problems of non scientific factors coming into play, is the rise of spin out companies (R-6)

Convergence may lead to: (dis)integration, specialism, auto-exclusion. .(R-1)

Range of skills needed mean that wide ranging teams are needed to make the best products finally and as such a European or transatlantic flavour is needed at some stage if developments are going to get serious. (R-12)

To-day the UK is level with the US in terms of innovative approaches but the scale of operation there will quickly roll others over, backed by the massive NNI Act. (R-12)

This is just a matter of personal view: In basic research I expect that there will be increasing competition with the exception if political decisions (home security) forces the US to collaborate. (R-5)

In applied research we will probably see a difference rather between small regional and large multinational companies. (R-5)

Hard sciences could provide the methods for attempting to resolve problems posed by the social sciences. (R-1)

UK needs more technology transfer staff to ensure a dynamic system from research to technology (R-6)

Research in a few areas of nanotechnology development indicates a form "limited collaboration".(R-11)

Patents or some type of collaborative ownership model is important in sustaining research partnerships, to include the attraction of university professors at most Canadian public research universities but it is eventually inevitable that intellectual collaboration across borders is taking place. (R-11)

Flexible indicators and evaluation criteria are needed. Truly multidisciplinary standards are necessary. In their absence, no convergence will magically happen *per se*.(R-1)

Unites States has much stronger commercial sentiments. This results in much more than commercial products however. It means that: (1) research is self-funding; and (2) the fruits of research are more likely to actually get used. (R-2)

Europe appears to have a greater spirit of collaboration, but if it is merely cooperation among research institutions, without a continuity of interest that spreads to the end user community, then Europe will have the same problem as Canada, only bigger. (R-2)

What Asia is up to is a big? (R-5)

Research must have a global flavour, that is any result should be useful all around the world (R-10)

3. Society driven R&D

Q3) The NTW expert group is premised on the idea that (groups in) society might accomodate convergent technologies more easily if the European research agenda is properly focused and defined.

A. Can Society do this?

- 3A: Do you believe that this can be done?

Yes, but the scientific community should be involved at any steps of the decisional process. (R-1)

Yes, but it should be aligned with some end benefit or capability in mind. There must be some view of how the results of research will span the innovation continuum and drive some utility, via

- Corporations Focus - by specifically directing research efforts towards producing technology that they know they can sell, or use within their own processes. This does not preclude fundamental research - IBM researchers have collected three Nobel Prizes.
- *Dirigiste* economies with strong entrepreneurial cultures (Taiwan) have successfully targeted application areas and built the infrastructure necessary to capture global market share.
- Mission Objectives - Within competitive markets, some sectors (e.g. the military in the U.S.) can playa significant role in directing R&D, because of a mission. (R-2)

People are scared of science because they don't understand it, because within the science community it's considered a bit of a waste of time to talk to the general public. science should be central to life because it is central to life and there is a lot to the quote by Carl Sagan, the astronomer saying "*It is suicide to live in a society dependent on science and technology*", where hardly anyone understand anything about science and technology. Until we aim to have science mainstreamed in society then I think we are at risk (R-6)

From a science research perspective, if convergent technologies is only one aspect of European Research, then perhaps a more focused and defined agenda may help, but I would be sceptical in driving all nano research towards convergence. (R-11)

Yes, but the important thing is whether the research agenda is socially robust, which means it should be based on participatory, sound and combined analyses of societal problems and solutions (R-9)

Will CTs be applied in a few niche areas, or in many different areas? If the former, then much of the hype around the CTs could simply result in much misplaced investment; if the latter, the potential exists for a much greater impact on society and the environment than can possibly be forecasted. (R-3)

Just because the technology has the ability to transform what humanity means it is important that a broad information and education will lead to a public participation in the decision making. (R-5)

Current social sciences are up to support this task. (R-5)

It is needed to identify emerging social, ethical, and economic issues in order to facilitate social steering of the new technologies. (R-11)

B. How would they do it?

3B: What kind of research focus or definition might do the job? (R-1)

Directional funding of research to govern the process. (R-1)

Why? A focus might help to define the starting point. Beyond that it is more important to have an idea about what this should be good for (in the society). If at all, the focus should be provided from a needs assessment and not from the supply side. (R-5)

The role of industries in deciding funding priorities is a very critical step. (R-1)

Selected opinion-leaders, visionaries, should be given a formalised role. (R-1)

Utopian proposals are in many cases more interesting than short term concrete ones (R-10)

A Systemic research focus may perhaps assist. (R-11)

Imagine ways in which scientific research is again integrated to the need of a community (R-6)

R&D agendas, projects and results need to be subject to much more public scrutiny (R-9)

As far as researchers themselves are concerned, the issues largely relate to differing scientific languages, concepts, culture, trust and so on (R-9)

The centre concept is pervasive in the literature on how to support cross-disciplinary research. The US, the UK and many other OECD countries, have taken the step of funding designated “cross-disciplinary” research centres. Cross-disciplinary activity is the norm not the exception in these cases. (R-8)

European research agendas are only useful if they are adaptive yet flexible. Public ones are not and the overheads of the FP increase year on year, There is a European role to play for the definition and dissemination of good practice, standards for handling and disposal of experimental waste and a dialogue for citizen participation. But this should focus on risk management rather than market priming! (R-12)

A 2-tier strategy can be envisioned: selected leaders Darwinian selection of targets, necessity of long-term strategies, short-term programmes. Flexible management, avoiding bureaucratisation. (R-1)

Research focusing on solving broadly recognised societal problems, rather than technological driven research (R-9)

Clearer borders between university research and industrial development is needed in order to secure independent and socially robust research at the universities (R-9)

It is only through informed debate and a process of social learning by which benefits can be realized responsibly and equitably, with risks properly taken into account. (R-11)

The key issue is in my mind, how to mainstream science to the political agenda. Currently the media and public opinion set the political agenda, if the public are informed about science by journalists we are lost, as they generally know little about S&T and so we are locked in a degenerative cycle. More scientists must get involved in politics (R-6)

More specifically: a clear focus is an important starting point, but it is of paramount importance to monitor the actual effects of the research (medium-term). (R-1)

The job should be mostly done by the research community, counterbalancing predictable biases and conflict of interests. (R-1)

Initiative needed to established an accurate measurement of the convergence of NBIC utilizing bibliometric tools, quantitative and qualitative data on effective technology development policies (R-11)

In areas where there is already substantial research, Canada is building institutions that can coordinate and 'optimize' research efforts. Thus we have the Canada Institute for Health Research (CIHR) to look at all programs receiving funding for health and medical-related R&D. Also, a new position of Science Advisor to the Prime Minister has been created. (R-2)

Industry Canada is taking a close look at the use of technology road maps as a means for coordinating research efforts for all stakeholders in industry sectors. The focus, in this case, is an emergent behaviour that comes as a result of many players acting off the same script. (R-2)

CTs might certainly be viewed as being potentially pervasive throughout the economy. Such GPTs are endowed with three salient characteristics: (1) they are employed in a wide range of application sectors, products and processes; (2) their efficiency is inclined to continuous improvement; and (3) they co-evolve with other new or existing technologies.1 A GPT should also be capable of lifting the entire world economy onto a new plane of higher growth. Examples of previous GPTs include steam, electricity, digital computing, the internal combustion engine, the railways, and motor vehicles. (R-3)

4. European Strengths and Weaknesses

Q4) What perceptions of threat and opportunity will serve as incentives and barriers to the dissemination of convergent technologies in Europe?

A. Strengths

The Commission is the only hope to enable Europe to act together and ensure a strategic market role for the future. It is just not acceptable for once country to control all the IPR on these technologies, nor healthy for innovative development. (R-7)

EC must promote convergence and integration should be the natural consequence (R-10)

When we look at potential, we assume that technological capabilities will be put to some good use. But in a consumer culture we are more likely to turn resources into junk. (R-2)

There are a number of specific European qualities that will distinguish our approach from that of other regions in the world. One is the multilingual (and multi-modal) form of communication which is rather different from say the US situation (with a single language). (R-4)

The best institutions of the future are those that can re-organise themselves to address scientific and educational questions in an interdisciplinary way. (R-9)

Lifescience research will drive this convergence and should be an intricate part of convergence measurement. The Human Cognome Project will certainly accelerate the application of genetics (human and plant) into technological applications but will not measurement nano-technological advancement (R-11)

Another of these qualities is the diverse cultural "content" in our societies which needs to be taken serious within "AmI" and again offers the potential for immense market opportunities. (R-4)

The worst would be that the Europeans would feel to be left out of the development and lag behind as a result of their incompetence. An incentive on the other hand would be if the European research and industry could develop specific developments which relate to our cultural heritage and couldn't therefore be easily copied. (R-5)

A value based approach (sustainability etc.) could be open new venues. (R-5)

A European Vision must have the Capability to promote and realize completely new solutions capable to subvert older ones; the first consequence of NBIC is a revolution of ethical and, in part, cultural principles (R-10)

Propensity for human beings to like to live in smaller groups, it could be that in the future what we should be aiming for is to encourage that much smaller community within the much bigger federal Europe (R-6).

B. Weakness

Opportunity to improve the economic status of a sub-group is a major incentive. (R-1)

Opportunity to establish a cultural leadership is also important *per se*. (R-1)

There is an urgent need to ensure that new IPR created in converging technology areas – which in itself maybe of a peculiar nature – is well protected and the rights and financial rewards go back to the innovators who have had to prime their work often from own funds. (R-12)

Spontaneous collaborations - when you try and contrive things, like any contrived marriage, it doesn't really work easily, or as well as when people can meet spontaneously and they discover themselves that they have things in common. (R-6)

European research agendas are only useful if they are adaptive yet flexible. Public ones are not and the overheads of the FP increase year on year, while Unilever have shown an international research agenda can be maintained and can lead to considerable benefits to the center of the organization (r-12)

One of the **big problems is language**. That might be one indicative barrier but one of the interesting issues (R-6)

Barriers may emerge e.g. at the national(istic) level. They may be lowered when the sharing of the benefits are proactively understood. (R-1)

The scientific milieu, particularly in Europe, is not literate enough about cost - and benefit-sharing. (R-1)

We really can only speculate on capabilities at this point, and these are merely a proxy, for actual impact (R-2).

The potential of the telephone was only partly evident in its early stages of diffusion, no one could guess how it would transform society once it became universally adopted. (R-2)

NBIC research is much more capital demanding than research and measures within basic prevention of social, environmental and health problems (R-9)

NBIC research might tie the public research budgets 'for ages' without solving important societal problems (R-9)

If NBIC solutions have a social bias towards the richer people, it can create market demands (R-9)

If NBIC have a social bias towards the richer people it might at the same time create social instability (R-9)

The institutions that will have difficulty are those that keep the same rigid structure that prevents pollination among disciplines (R-8)

Education has not woken up to what is happening and if it does not wake up soon, it could be very frightening because we are going to try and impose on young people the type of education we were expecting (R-6)

Helping scientists become entrepreneurs without losing their scientific streak.(R-6)

5. Who are the Winners and Losers

Q5) Who are already or in the very near future the winners and losers of this rush toward convergent technologies, and how should we take them into account?

World rankings in nanoatechnology in 2003– Top 20 by publication and patents

RANK	Publications	Patents
1	S KOREA	USA
2	PRC	GERMANY
3	POLAND	JAPAN
4	SPAIN	FRANCE
5	ISRAEL	UNITED KINGDOM
6	INDIA	SWITZERLAND
7	BELGIUM	CANADA
8	AUSTRIA	BELGIUM
9	RUSSIA	NETHERLANDS
10	JAPAN	ITALY
11	FRANCE	AUSTRALIA
12	SWEDEN	ISRAEL
13	AUSTRALIA	RUSSIA
14	NETHERLANDS	SWEDEN
15	GERMANY	SPAIN
16	UNITED KINGDOM	S KOREA
17	SWITZERLAND	AUSTRIA
18	ITALY	PRC
19	USA	TAIWAN
20	CANADA	INDIA

Common issues

The “digital divide” is most troubling which brings the “haves” ever more advantages by the advancement of technology and keeps leaving out the “have-nots”. In fact, from a market point of view the less developed countries form the largest market, but they have not the means to pay for the technology. How to solve this intrinsic problem is a great political challenge. (R-4)

There is need for more true dialogue between research planners, universities, researchers and civil society (citizens and citizen organisations) about the research agendas (R-9)

Social sciences are affected by NBIC and, vice-versa, affect hard science and technology. (R-10)

Using Bibliometric studies, the current winners and loser with reference to nano publications and nano-patents. When comparing the publication data with patent data, this perhaps raises

questions about the absorptive capacity of nano-science of the countries with low patents. (R-11)

Publications vs. Patents: The world output for nano publications has almost doubled in the period from 1995 to 1999. The 20 most active countries (2003 data) in order of output are: SouthKorea (282.7), China, Poland, Spain, Israel, India, Belgium, Austria, Russia, Japan, France, Sweden, Australia, Netherlands, Germany, UK, Switzerland, Italy, US (65.3), Canada (44.9). While the world output for nano patents is quite different with US (42%), Germany (15.3%) , Japan, France, UK, Switzerland, Canada (2.0%), Belgium, Netherlands, Italy, Australia, Israel, Russia, Sweden, Spain, South Korea, Austria, China, Taiwan, India, Others (0%). (R-11)

A. Winners

International entities in which the methodological standards are high-profile, but also include enough "visionary opinion-leaders" and selected, skilled decision makers governing the realization of research. (R-1)

Groups solving the "critical mass" problem. The number of scientists in not *per se* important, despite the fact that a given phenomenon cannot be fruitfully approached unless enough specialists research perspectives are simultaneously in action. (R-1)

The "mass" has to be defined in terms of entities "obeying" to a charismatic leadership, and the recruiting system should be adjusted to a very limited number to leaders, selected by way of a very elitaristic process. (R-1)

The winners will be the bigger companies who can afford to pick off the minnows as they see winning technologies emerging at a time when the developers are often weak financially (often between 2nd and 3rd round funding and market or licence income). (R-12)

For now it looks as if the US might be (only) the winners. (R-5)

The winners are the richer people, the richer countries and the big industry (R-9)

Advancement of science is partially filling up the difficulties related to complexity. (R-10)

If one takes the demographic developments into account its seems that in the longer term future only a minority of the citizens of the US have really an interest in technology and high level research (R-5).

Only the leading edge can only be guaranteed, if immigration can continue and patent law doesn’t strangle the free flow of information. (R-5)

We are now facing a disconnect between the IT, the IT completely bilingual generation, - and the vaguely IT literate (R-6)

When addressing opportunities, the winners will be those who use the technology. This is not the same as those who produce the technology. (R-2)

Capturing benefits is the key, and collecting royalties is just one very small benefit. (R-2)

There will likely be discussion about divides between the "haves" and the "have nots". (R-2)

U.S. in the first place; China as second; India in the third place (R-10)

B. Losers:

Over-specialized, yet highly internationalised, research groups may be at risk. (R-1)

Europe (R-10)

Scientific entities which are paralysed by bureacracy. (R-1)

If Risks are not assessed and appropriate measures taken, we could all be losers. (R-7)

In the long term (some decades) our brain could be modified through brain- machine symbiosis (cyborg) (R-10)

The losers are the less-rich people, the poorer countries and small and medium industry (R-9)

Systems operating in absence of a peer-review stage in at least one phase of the decisional process about funding. (R-1)

In reality, the divide will be between the "cans" and the "cannots". Technical ability will be the key to capability. (R-2)

Institutional conditions and traditional **values** are much more **regional oriented**. I think what we can do is the use of IT in the virtual world, in transcending boundaries. (R-6)

How the technological integration is achieved for the new members of the EU. The danger is that these for a long time will not be fully integrated and a divide will remain in the forthcoming technological evolution. (R-4)

Probably once again the developing nations and Europe is somewhere in between. (R-5)

Unknown is Asia and particularly China. (R-5)

Losers will the those whose purchasing power will ensure they cannot buy into the latest product families, and as these will be increasingly interconnected they also risk exclusion. Developing countries will not be able to afford the technology to develop their own NN fabrication, though much UK work is based on affordable systems and products. (R-12)

Losers in the technological development, it goes without saying are the **developing world**, and here we are without Prozac[6], and our Botox[7], and our Playstations and so on, and our Game Boy thumbs[8] and our IT world and our genetic enhancement (R-6)

[6] anti-depressant
[7] anti ageing treatment

Losers are not just older people, but **the vast majority of people** in our current society who are not in the top 5% of IQ (R-6).

[8] **Thumbs are the new fingers for the GameBoy generation Amelia Hill, Sunday March 24, 2002, The Observer, UK** , Use of hand-held technologies, such as mobile phones, GameBoys and computers, has caused a physical mutation in the under-25s, according to new research

6. Risk Management

Q6) The risks associated with convergent technologies are unknown even to the point that often one does not know whether there are any risks involved and what they might be. How can we handle or address such unknown risks?

"Precaution" is not a principle, but an ideological premise; it can work in a well-known situation, but it is absolutely misleading in the case of completely new one (R-10)

A pervasive, growing and unappreciated threat lies in the area of dependencies on complex networks of technologies. The loss of a power grid, or the ability of a few fanatics to tie up transportation systems, are current examples. This situation will only grow worse as vital systems evolve beyond human control. (R-2)

Ability to gauge impacts and decide what are beneficial-negative impacts of new technologies. Science itself must give a lead. (R-7)

Advisory role to amateur-type associations, opinionists pressure groups, politicians, religious leaders, and other societal groups external to the scientific community. (R-1)

Any sort of moratorium would be disasterous and allow the US and increasingly China to run ahead. (R-12)

At its best, the management of risks and the invention of needs can be carried out together. In this respect, social research can facilitate and enhance the successful commercialization of CT. (R-13)

At the same time social research is likely to benefit the development and commercialization of the technology by introducing the likes and dislikes of end users in the innovation process. (R-13)

Attempts should be made to understand the wide ramifications of the issue. (R-3)

Confusion about the nature of technical change, a danger of focusing on unlikely outcomes and inappropriate policy that could delay and distort the public potential benefits of a new area of research. (R-11)

Consumers may not accept certain technologies when they are commercialized. (R-13)

Direct risks: environmental risks; land use risks; health risks; privacy risks etc. (R-9)

Even if the problems the technology will solve are not evident early on, preparing the general public is still a wise thing to do. (R-13)

If policy focused on systemic effects, a more accurate picture of risks and benefits could be articulated. (R-11)

Indirect risks: the way they influence the understanding of social, health and environmental problems and the way the solutions are shaped by NBIC (R-9)

It will be wise to develop new technology, but not at the expense of adapting and using imported technology. (R-2)

Monitoring the process of convergence. (R-1)

No precautionary principle. Only rigorous (provisional) analysis cost/benefit when it is possible (R-10)

One intriguing possibility is to create scenarios, and then build up the steps that would take us there. Then we could hypothesize actions that institutions would likely take. This process takes into consideration that we rarely undertake the bold actions needed to deal with dramatic scenarios. (R-2)

Potential issues of IPR for self-assembly systems as a major area of issue (R-7)

Precautionary principle – for scientific research at it's best - does not apply. (R-6)

R&D agendas, projects and results need to be subject to much more public scrutiny (R-9)

Risk Agency of sorts (like in the case of nuclear proliferation) which monitors the development and has the power of sanctions and also a way to make the society better informed to enable public opposition to certain developments. It would be particularly important that it is principally possible to stop a development (world wide). (R-5)

Risk Culture - Establish a "risk culture". I doubt that very many scientist, particularly when they are young, are aware of what they are really doing. The risk culture should extend equally to the politicians and to the public at large. (R-5)

Risks may wind up being widely distributed. (R-2)

Socially oriented research is needed to identify risks early on. (R-13)

Some of the bleak scenarios dealing with runaway nano- or bio-disasters would be devastating. (R-2)

Some risks become, of course, evident only after the technology has matured. (R-13)

The responsibility for technological risks should be handled mostly by those responsible for producing it. (R-13)

The systemic approach as a framework for investigation of risks and a timely investment is needed in social science research on nanotechnology and its social dimensions, to clarify what is happening now and what are the likely trajectories of nano-technological development. (R-11)

There is a European role to play for the definition and dissemination of good practice, standards for handling and disposal of experimental waste and a dialogue for citizen for risk management (R-12)

Understanding the technology better. So far we don't excel on this even with the technologies we have already at hand. (R-5)

We can and must take all reasonable precaution, when we see risk we must investigate it – any thereby maybe also enable new products or services to emerge. Studies like the one being undertaken here in-house at the Royal Society must be open, transparent and receive maximum exposure once public. (R-12)

We really don't have much of a backup plan. (R-2)

When analysing the implications of technological change, as realistic an outcome as possible should be the objective (R-3)

Will CTs be applied in a few niche areas, or in many different areas? If the former, then much of the hype around the CTs could simply result in much misplaced investment; if the latter, the potential exists for a much greater impact on society and the environment than can possibly be forecasted. (R-3)

To be consolidated

Late receipts, which will be integrated later in a revision after the June meeting. The tables above have been updated but text not allocated to sub sections of the commentary.

Q1) What do you consider the most beneficial, and what the most troubling development to come out of convergent technologies within the next 10 years?

+

Beneficial if convergent technologies (CT) would lead to cheaper and better quality solutions to current problems. (R-13)

New medical solutions, for example, which are cheap would benefit the whole world. (R-13)

Many problems of everyday life have already been solved. Plumbing, vaccines, electricity and telecommunication, for example, no need to reinvent! (R-13)

-

If CT focus on issues which are not considered societally important there is a risk that their contribution becomes neglected. Therefore, the social impacts of the technologies should be considered alongside the technological impacts. (R-13)

Q2) Consider research on convergence in your own country or your own field in respect to national, global (US), and specifically European trends:

- **A Do you find that that research would pretty much look alike anywhere or does it have a regional, national or European flavor?**
- **B How does the national research position itself in regard to similar research in the US or Europe - by way of cooperation or competition?**

A

In my own field there is a national and regional flavor in the research. (R-13)

Many markets, institutions, regulations and even companies are national to their character. (R-13)

It would be too easy to attribute the differences to different cultures. (R-13)

B

Qualitative research needs a certain level of volume. Research projects funded by the European Union are in this respect very important. (R-13)

The technology is global, which also makes the research more global to its nature. (R-13)

Similar issues are evident in many countries. Just the solutions and settings differ slightly. (R-13)

There is much European cooperation in the research as the European framework is convergent. (R-13)

Competition is good to keep research quality high. (R-13)

There is more competition with research from the United States. This competition relates to different approaches of ICT. (R-13)

It seems that Europeans are ahead in mobile communications and Americans in computing. (R-13)

Q3) Our expert group is premised on the idea that (groups in) society might accomodate convergent technologies more easily if the European research agenda is properly focused and defined.

- **Do you believe that this can be done?**
- **What kind of research focus or definition might do the job?**

Focusing and designing a European agenda is likely to accommodate CT more easily. (R-13)

Agendas call for proper focus and design, on issues which are considered important by Europeans. (R-13)

The social dimensions of CT should be given much attention. They matter to people. (R-13)

Q4) What perceptions of threat and opportunity will serve as incentives and barriers to the dissemination of convergent technologies in Europe?

It would be a shame if the potential of CT would be neglected due to the public misunderstanding the technology. (R-13)

The consumer interface is important. (R-13)

Consumers can hinder or at least slow down the adoption of technology if it not considered meaningful or even distrusted. (R-13)

Consumers are usually more concerned with how new technologies can contribute to good life rather than with how their life can be made more efficient. (R-13)

Acceptance is more likely if CT are simply a continuation of earlier technologies and used in intermediate parts of the production process. (R-13)

When CT challenge conventional thinking the building of acceptance will take more effort and its outcome will not be evident. (R-13)

The misuse of technology is not a new phenomenon. We already see examples of how products and services are intentionally degraded and overly controlled after sales. In addition to inconvenience and loss of efficiency, this leads to privacy problems. CT potentially offer the possibility for greater control of individuals than before. (R-13)

Q5) Who are already or in the very near future the winners and losers of this rush toward convergent technologies, and how should we take them into account?

The medical industry is a likely winner. (R-13)

In order for the gains of CT to be transmitted to consumers, authorities possibly need to intervene with measures affecting patents, marketing and intellectual property. (R-13)

The food processing industry has to date not been able to convince consumers. (R-13)

Technologies involving functional foods and gene manipulation have not been particularly welcomed. (R-13)

Food is a delicate matter for consumers and the industry should have paid more attention to consumer concerns. (R-13)

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