Foresighting the New Technology Wave
SIG I – Quality of Life

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SUMMARY

The SIG1 has identified a suitable set of Quality of Life Indicators (The Calvert-Henderson Indicators) which were judged best suited to the task to identify how the converging technologies, Nano-Bio-Info-technologies and the cognitive sciences were likely to impact on the quality of life in Europe under four disparate scenarios. The converging technologies were assessed to have the greatest and most positive impact under the Dragon scenario (very similar to the Europe which should develop along the lines outlined in the Lisbon Declaration).
Further work then identified a number of the more important examples of convergence which would have a major impact, and by so doing provide opportunities for European industry and society, on six key QoL indicators, Education, Health, Energy, Infrastructure, Environment and Public Safety (including security). Inputs to the main report includes examples of CT applications.

Objective

This was initially to establish the impacts, positive and negative, of convergent technologies on the quality of life of the European citizen under the four scenarios for the future identified by the HLEG.

Methodology

The group has a fluid composition (Morgan, Polsek, Saxl, Fitzmaurice, Nakicenovic, Tassin all participated) and met whenever possible alongside plenary sessions. Five Steps were planned to be undertaken:

1) Develop and circulate questionnaire to HLEG, which will provide a starting point for the assessment of the impact of convergent technologies on the quality of life of the European citizen under four scenarios for the future.

2) Evaluate response to questionnaire from HLEG and identify those areas of the grid that are seen as corresponding to the highest impact on quality of life of the European citizen under each of the four scenarios.

3) Present to the HLEG a description of the ranked impact of selected convergent technologies on the quality of life of the European Citizen under each of the four scenarios.

4) Identify convergent technologies that will impact on those areas of the grid that have been identified as corresponding to the highest impact on quality of life of the European citizen under each of the four scenarios.

5) Complete analysis based on input from HLEG and submitted to the Bureau and the Plenary for June 14th, 2004.

Selecting the QoL measure

This was a critical decision and took much debate, only taken in the timeframe of the 3rd meeting in Leuven of April 2004. The group was not expert in any one of the sets of indicators but used the mission statement of the whole group to exercise judgements on the suitability of each methodology.

The Calvert-Henderson Quality of Life Indicators were selected finally. They are the result of a collaboration between international futurist Hazel Henderson, the asset management firm Calvert Group, the research company Flynn Research, and scholars with expertise in 12 dimensions of quality of life in the USA. Those dimensions are: education, employment, energy, environment, health, human rights, income, infrastructure, national security, public safety, re-creation and shelter.

The group chose them after a reflection of other initiatives, such as:

Eurostat Environmental Indicators[1] - "Eurostat" is the Statistical Office of the European Communities. Its task is to provide the European Union with statistics at European level that enable comparisons between countries and regions. The indicator set was too oriented towards purely environmental indicators, and collected only in patterns determined by the EU's Member States.

Wellbeing of Nations[2] is a Country-by-Country Index of Quality of Life and the Environment[3]. It is a global assessment of sustainability that surveys 180 countries using the "Wellbeing Assessment". Developed with the support of the International Development Research Centre (IDRC) and IUCN, the Wellbeing Assessment includes a Human Wellbeing Index and an Ecosystem Wellbeing Index to give equal weight to people and the environment. It was considered to be too biased to ecosystem balance. Four separate indices are usually employed: the Human Wellbeing Index (HWI) and the Ecosystem Wellbeing Index (EWI) (which together form the Barometer of Sustainability), the Wellbeing Index (WI) and the Wellbeing/Stress Index (WSI). The WI shows how well societies combine human and ecosystem wellbeing and hence how close they are to sustainability, while the WSI is the ratio of human wellbeing to ecosystem stress (i.e. the opposite of ecosystem wellbeing) and shows how much harm a society does to the environment for its level of development. In the backgrounder to the survey, it is said that the WI and WSI "break new ground by measuring people and the ecosystem together to compare their status, show the impact of one on the other, and focus national and community energies on the improvement of both". It was too specific for this purpose though.

The "State of the Nation's" Ecosystems[4] - Measuring the Lands, Waters, and Living Resources of the United States, November 2001 by the H. John Heinz III Centre for Science, Economics and the Environment, this report provides a foundation for a comprehensive, credible series of periodic reports on the state of USA ecosystems, but for the SIGs purpose too imbalanced.

2001 Environmental Sustainability Index (ESI[5]) - An initiative of the Global Leaders of Tomorrow Environment Task Force, World Economic Forum, Annual Meeting 2001, Davos, Switzerland. The Environmental Sustainability Index (ESI) is a measure of overall progress towards environmental sustainability, developed for 142 countries by a collaboration of the World Economic Forum's Global Leaders for Tomorrow Environment Task Force, The Yale Centre for Environmental Law and Policy, and the Columbia University Centre for International Earth Science Information Network (CIESIN). The ESI scores are based upon a set of 20 core "indicators," each of which combines two to eight variables for a total of 68 underlying variables. The ESI permits cross-national comparisons of environmental progress in a systematic and quantitative fashion. It represents a first step towards a more analytically driven approach to environmental decision-making, but was considered too complex for the SIG's objectives.

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[1] For more information see the report "Measuring progress towards a more sustainable Europe" in the Environment and Energy section of http://europa.eu.int/comm/eurostat/Public/datashop/print-catalogue/EN?catalogue=Eurostat

[2] For more information see: http://www.iucn.org

[3] by Robert Prescott-Allen, 2001, Island Press

[4] For more information see: www.us-ecosystems.org

[5] For more information see: www.ciesin.org/indicators/ESI. For a critique of the ESI, see: The Ecologist and Friends of the Earth, "Keeping Score: Which Countries Are the Most Sustainable?" (The Ecologist, Vol. 31, No. 3, April 2001, p44) in the archives at www.theecologist.org

Calvert-Henderson Quality of Life Indicators

The Calvert-Henderson Quality of Life Indicators is a US based ethical investment fund development that is employed to direct mainly pension fund investment towards long-term sustainable investments. As such the SIG felt they were appropriate vehicles to carry ambitions to promote greater investment in RTD as exemplified in the Lisbon Agenda. They are also a contribution to the worldwide effort to develop comprehensive statistics of national well-being that go beyond traditional macro-economic indicators. A systems approach is used to illustrate the dynamic state of our social, economic and environmental quality of life. The dimensions of life examined include: education, employment, energy, environment, health, human rights, income, infrastructure, national security, public safety, re-creation and shelter.

Another key advantage is that they can be used to bring key decision makers quickly up-to-speed on the state of each domain. Researchers are able to download current and historical data streams, and so the SIG output can be contextualised, see http://www.calvert-henderson.com/meth.htm. Media (the NTW EG consider the media to be a non-neutral party here) can gain insights from experts in each field who highlight and explain subtle trends that affect our daily lives.

Education	The Calvert-Henderson Education Indicator provides an overview of issues related to structural educational reform, school vouchers, "charter" schools, home schooling, and the globalised information-based economy. Knowledge is now widely recognized as a significant factor of economic production and a basic human right. Nothing is changing business and academic institutions faster than the new definitions of human and intellectual capital-on which technical and social innovation is based. But as many new Internet and e-commerce businesses know, a company cannot own the part of its knowledge base that resides in the heads of its employees, yet it sometimes represents the majority of their “market” value.
Employment	One of the hallmarks of politics, academia, and activism is the integration of three previously distinct fields: economics, social welfare, and the environment. This integration helps deepen the dialogue about quality of life by employing a systems approach to make explicit the inherent interdependences between factors impacting quality of life. The downside, however, is that issues are viewed as more complex, which naturally leads to hotly contested public policy debates and sometimes direct conflicts between people who in their hearts support similar values. Examples include today's debates about trade policy, outsourcing manufacturing and increasingly services like call centres to countries with lower wages such as Mexico, China and India. There is also the debate about immigration and whether immigration decreases or increases economic growth.
Energy	Energy is the lifeblood of the economic process. It provides light, heat and air conditioning for homes, schools and businesses. It powers office equipment and production machinery, and it supports the transports of people and freight. Energy, especially in the form of petroleum resources, is also a critical ingredient in a diverse mix of consumer goods, ranging from medicine and children's toys to food and clothing. But the inefficient use of energy can act like a brake on the economy, contributing to growing pollution and economic slowdown.
Environment	The Indicator seeks to embrace the interactions between human society, economic processes, and humanity’s life support systems: the natural world, its resources, and other species. The burgeoning field of environmental indicators and sustainability criteria are drawn upon, including data on planetary ecosystems, the crucial role of biodiversity, and human effects on the ozone layer and climate. While recognizing these broad concerns, the initial focus of the Environment Indicator is on air and water quality since people cannot survive without acceptable quality air and water. Through these lenses, one can understand better the causes of their degradation and pollution and the many steps needed to reverse these threats. The systems approach reveals that many other domains of quality of life, such as infrastructure design, energy use, shelter, health, employment, public safety, and national security, all impinge on the environment and life support systems.

Health	Health has been defined by the World Health Organization as "a state of complete physical, mental and social well-being". It thus transcends the absence of death, disease and disability, and incorporates concepts of well-being and quality of life; measures of health must likewise transcend mortality and morbidity. However, health does not exist in isolation, but rather it is the product of the interaction of our natural and built physical environments, socio-economic status, psychosocial conditions and cultural norms and beliefs with our physiological and psychological selves and our genetic inheritance. To reflect this complexity, the Indicator focuses on three basic questions: "Who gets a chance at life?" "How long will that life last?" and "How healthy will that life be?" Infant Mortality Rate is a measure of the first question, Life Expectancy is a measure of the second question and Self-Reported Health is one way of measuring the third question.
Human Rights	Defining human rights is controversial, particularly because it is deeply rooted in moral philosophy, notions of justice, and respect for human beings. The Indicator provides a tool for viewing and evaluating rights in a society. The indicator examines the state of human rights in broad areas: fundamental rights to security of person in the private sphere (e.g., freedom from domestic violence, access to food, nutrition, medical care, and clothing) and the Bill of Rights and other amendments to the Constitution [US-and eventually the EU] established to protect our rights in the public sphere where these exist (e.g., freedom of expression, religious freedom, rights of assembly, voting rights). The indicator covers incarceration data, the death penalty, prison labour, racial/gender discrimination, rights of minorities and other [indigenous people, mistreatment of prisoners and aliens, as well as voting rights, participation in politics, and the growing influence of money and special interests. The Human Rights model also embraces an evolving international view embodied in the International Bill of Rights (1996) and the Universal Declaration of Human Rights (1948), which cover civil, political, economic, social, and cultural rights. These and other issues have become a keystone of much of foreign policy as we begin to see movement toward a reformulation of human rights in ways that integrate not only the private and public rights of women, men, and children but also political, social, and economic rights and responsibilities.
Income	"Income" focuses on trends in the standard of living as reflected in monetary measures of family income. The trends in the level and distribution of family income since 1947 are explained with a particular focus on what has been the key determinant of family income trends - changes in hourly wages. Growing income inequality since 1973 is explored, along with changes in people's wealth holdings. The Income Indicator offers a provocative and thoughtful way to assess our economy's performance in raising living standards during the global economic boom of the early 1990s.
Infrastructure	This un-bundles macro-statistics to reveal an ongoing debate: To what extent has Europe been overlooking the vital role infrastructure plays in under-pinning its economy? Historically, infrastructure referred to highways, railroads, harbours, bridges, aqueducts, public buildings, dams, and the like. Industrial societies evolved airports, communications systems, energy supplies, water, and other utilities, and EU regional and cohesion funds have focused on that, but in the past decade more emphasis has been place din telecoms networks Today, infrastructure includes education, research & development, computerized systems, and all taxpayer-supported systems used in commerce. The indicator picks up the recent trend to privatise growing areas of formerly publicly-owned infrastructure, including electric utilities, phone, water, and other services Also such investment lifespan are up to 100 years, and public accounting systems and investments took that into account, but new age infrastructure often has life spans of under a decade, and may need radically new investment f universal services are to be offered.
Security	Security is a state of mind, something we feel or sense. It is a way of being affected by and having an effect on the world, rather than an absolute state of existence that can be precisely defined in everyday life. Nonetheless, some people have strong views about the state of national security, with one person believing (for what seem valid reasons) that the nation is secure from its enemies while another (for equally valid reasons) sees great dangers looming. The process and pressures that impinge on the formation and execution of national security policies are examined, ranging from the public's perception of a threat of war, to national security strategy. Expectations include that foreign terrorists will strike a major economy sometime before 2020 or 2025 are high; a rise in the number of major armed conflicts throughout the world; sharp jumps in both arms transfer deliveries and world military expenditures; and the potential for petroleum-producing states to start buying arms again (with rising oil revenues) and disposing of old weapons to less wealthy countries. The Indicator shows imbalances between military strategies and preventive activities through diplomacy.[6]

Pub. Safety	How effectively our society promotes safety — as measured by those instances when we have failed to prevent outcomes that result in death or injury. The vast majority of injuries and deaths stems from events that do not fall into the definition of crime. Safety means a safe physical environment, including safe products and safe roadways. Supporting safe personal behaviours has always been an important part of improving the safety of the population. But it is also necessary to acknowledge what can be improved in the public sphere. Reducing deaths and injuries from cars and guns, will require changes in the public sphere. To do so, we need to foster cultural values that support public action as well as personal behaviours as essential determinants of safety.
Recreation	Recreation involves re-creating oneself - to be revitalized in body and mind and to affirm or extend social contacts. Adults now spend upwards of a quarter of their time in recreational activities, which compete with other activities, attention, and personal budgets. The Indicator is a novel way to better understand how recreational preferences are shaped and the vital contributions of recreation to our quality of life. Thirteen major types of recreation are explored, ranging from self-improvement and religious activities, to participation in the arts, hobbies, virtual games, sports, social celebrations, gambling, and travel. The illuminating information attests to the cultural democracy ever present in humanities pursuit of life, liberty and happiness…not least manifested in increased short haul air travel for leisure breaks, putting hitherto unknown towns and cities on the map.[7].
Housing	Many EU (and the US) economies entered the 21st century with a booming housing sector characterised by rapidly expanding homeownership, record home sales, strong house price appreciation, and vigorous housing construction. During 1997-1999, more households became homeowners than in any other three-year period in history. E.G. <5% of Americans live in overcrowded homes with incomplete plumbing. The Indicator reveals that while the great majority of Americans are well housed, housing-related problems such as affordability and spatially concentrated poverty persist. Inequality in the US is nowhere more evident than in the persistent disparities in shelter across racial and ethnic groups

Methodology employed[8]

The research methodology designed for the Calvert-Henderson Quality of Life Indicators is grounded in the work of Thomas S. Kuhn as articulated in *The Structure of Scientific Revolutions* (1962).

Kuhn examined the process of transitions in science and how new theories emerge to explain the evolving world. Struck by the number and extent of overt disagreements between social scientists about the nature of legitimate scientific problems and methods, Kuhn attempted to discover the source of such differences. Kuhn advocated a reorientation in the evaluation of familiar scientific data as they are continually impacted by changing external intellectual and economic conditions. Along with fellow historians of science, he posited that perhaps science does not develop through the accumulation of individual discoveries and inventions. Rather, research will reveal fundamental novelties or anomalies that challenge substantive conclusions to key scientific questions. When this occurs, the natural tendency is for the scientific community to defend its preconceived assumptions. However, the anomalies will not be suppressed for long. At some point scientists begin "extraordinary investigations" that lead to a new basis for the practice of science. Here we are faced with the convolution of several of those moments possibly.

New theories imply a change in the rules governing the prior practice of science. Such paradigms or theories add value by drawing from an existing body of concepts, phenomena, and techniques to help explain new facts or information. Kuhn writes that "in the absence of a

[8] Research Methodology by Patrice Flynn, Ph.D, see http://www.calvert-henderson.com/meth.htm

paradigm or some candidate for paradigm, all the facts that could possibly pertain to the development of a given science are likely to seem equally relevant".

This sets the stage for further scientific developments in the field of rigorous empirical measurement of quality of life. The Calvert-Henderson Indicators put forward a new pattern to organise reflective thinking about quality of life in the modern age. Not least, they have proved useful in an ethical investment environment that exhibits robust characteristics when the market tends to be bearish[9]

Measuring the Quality of Life

There are two standard approaches to measuring well-being employed by social scientists today. The first is the *index number*, which tracks changes in a selected phenomenon over time. Indices are common in economic analysis. The Gross Domestic Product index, for example, measures production; the Consumer Price Index measures inflation. In the language of economists, the fundamental problem upon which the index analysis rests "is that of determining merely from price and quantity data which of two situations is higher up on an individual's preference scale" (See Samuelson in Basic Economics).

Index number theory is limited in that we assume an individual's tastes do not change in the period under consideration or if more than one person is considered, that their tastes are identical. Another limitation is that unless the reader is thoroughly familiar with the model employed to develop the index it is not transparent what variables are included and excluded or the relative weights assigned to each variable. Scholars in the field of quality of life have documented these and other methodological difficulties over the past few decades in such journals as *Social Indicators Research* and *Social Indicators Network News*. While powerful when fully understood and well fitted to the data, index numbers can be very limiting when trying to understand a topic about which a person is not familiar.

The second approach to measuring quality of life comes from the field of community indicators, currently involving over 200 groups in the United States. During the 1980s and 1990s, the quality of life movement re-gained the attention of citizen groups, scholars, practitioners, policymakers, and private foundations interested in alternative measures of well being beyond those created by economists and other social scientists. An increasing number of groups began redefining well being at the neighbourhood, community, or city levels in ways that expand the traditional parameters of the National Income and Product Accounts (NIPA). A host of new and innovative data sets are being identified, collected, and analyzed. The quality of life literature is expanding rapidly as the concept is integrated into the mainstream of life in America and as the growing movement for liveable communities intersects further with local, state, and national policy-making.

Hence, participants in the quality of life movement may be ready for the next phase of "measuring what we treasure," as Hazel Henderson noted in *Paradigms in Progress* (1995). It is common parlance among participants in local community indicators projects to describe the GDP as a less-than optimal measure of the progress of the nation or community. Alternative measures are in abundance; many bytes of data are collected and stored. Missing at this junction, however, is a methodology for organizing, synthesizing, and analyzing these myriad statistics in ways that allow the bytes of data to be transformed into meaningful "indicators"

that can help citizens understand and influence complex social, economic, and environmental phenomena. The Calvert-Henderson models offer a solution to this problem[10].

In the context of the SIG WG, measurement is not an issue, as the only issue at stake is the relative ordering and prioritisation of the indicators relative to one another, but the SIG bears in mind that downstream of any recommendations of the group the potential impact has to be assessed in a framework that is both scientifically based, and captures the hopes and aspirations of the citizen in general, and at least as well as the inevitable series of economic indicators and feel good indexes. Therefore the deeper understanding of the 12 indicators and their provenance is important.

Summary of Scenarios developed by the New Technology Wave EG

The sub-group for Scenario development considered that three key forces determine Europe's orientation in NBIC research:

- **Public attitude to science and technology**
- **Europe's view of itself – culturally diverse or seeking homogeneity – with the associated political implications**
- **Europe's ambitions for economic growth, as expressed in the Lisbon Declaration.**

They developed a number of scenarios, and the approach to science and technology research in general and NBIC in particular under each could be described as follows:

Dragon represents the "official future" as expressed at the Lisbon summit. Here, Europe would use science and technology to modify old industries and create new ones, focusing on export opportunities. Examples are

- topics related to sustainability, e.g. fuel cells, potable water, pollution monitoring
- health needs to develop export markets world-wide
- products for French & Spanish speaking cultures
- niche products for different climates

Alter would focus on industries facing structural change, using research to take them to a new totally sustainable economic model. Examples are:

- technology to support decentralisation
- energy smart solutions, e.g. bio-engineering to produce hydrogen
- programs to solve the greenhouse effect e.g. bio-engineering of plants to accelerate carbon dioxide take-up
- telemedicine
- artificial intelligence in support of education & the creation of know-how
- monitoring of the eco-system

McDonalds would concentrate research on export opportunities of capability, innovation and specialist products. Examples are:

- topics related to preventive health care - . predictive medicine, understanding human genome in terms of early diagnostics, epidemiology/public health, ecology, life style regulation technologies, IT technologies for analyzing huge data sets to aid the sciences
- brain enhancements that enhance information storage & retrieval
- Basic science still needs to understand relation between genes and diseases, which lead to medical technologies; also it requires technological support, for instance nano-technological analytic methods.

Hubbard & Cupboard would focus on promoting inclusivity, with research on:

[10] Calvert-Henderson Quality of Life Indicators book, cost $24.75. Calvert-Henderson Quality of Life Indicators, PO Box 30348, Bethesda MD 20814.

- cognitive issues
- bio-ICT issues
- harnessing new bio-/geno-technologies to extend significantly lifespan as well as quality of life. Emphasis on prevention rather than cure – reduces need for expensive "reactive" therapies
- robotics & artificial intelligence.
- topics related to sustainability, e.g. fuel cells, potable water, pollution monitoring

The topics which appear in all the scenarios are those related to health – preventive medicine, telemedicine, tailored pharmaceuticals, bio and ICT monitoring, etc. A focus on health & ageing would appear to be robust across all scenarios for an NBIC programme. Sustainability (e.g. bio-engineering to produce hydrogen, programmes to solve the greenhouse effect, fuel cells, potable water, pollution monitoring) could be a robust focus if allied to export markets and export of capability, and used to drive economic growth. The use of ICT is embedded in all the scenarios, as are assumptions about enhanced ICT capability and the knowledge economy - although this is not spelled out.

Cognitive issues and brain enhancements are not seen in the scenario where the public is negative about science and technology ***(Alter)***. Common to all scenarios are links between universities, research, and industry. It is reasonable to look to a regional structure to implement this co-operation in all the scenarios. The scenarios that are based on economic growth (***Dragon, McDonalds***) have also a strong emphasis on basic research excellence.

The final names of the Scenarios is subject to change

QoL and the Scenarios

The entire NTW EG were asked to rank clusters of QoL factors against a set of Scenarios produced in a parallel but unconnected exercise (see . They were asked to respond on the priorities in the context of their own personal experience and context in their own branches of sciences or humanities. About 15 of the NTW EG responded with fleshed out QoL factors and rationales. These three clusters were broadly:

- the physical environment
- the intellectual environment, and the
- emotional environment.

It seems that there is often little differentiation between the latter two states of mind. In each cluster, for each of the 12 QoL indicators, one of 5 markings was possible:

+2 Strong positive relationships between the QoL and the attainment of the Scenario
+1 Some positive relationships between the QoL and the attainment of the Scenario
0 Neutral or no relationships between the QoL and the attainment of the Scenario
-1 Some negative relationships between the QoL and the attainment of the Scenario
-2 Strong negative relationships between the QoL and the attainment of the Scenario

Two statistical indicators were important here – the total summation score and the absolute summation score, see the table below:

Scenario	Physical		Intellectual		Emotional		Totals	
Dragon	105	121	76	90	59	83	240	294
Hubbard and Cupboard	70	98	72	96	63	87	205	281
McDonalds	47	117	42	86	18	78	107	281
Alter	44	98	52	94	57	81	153	273
	SUM	ABS SUM	SUM	ABS SUM	SUM	ABS SUM	SUM	ABS SUM

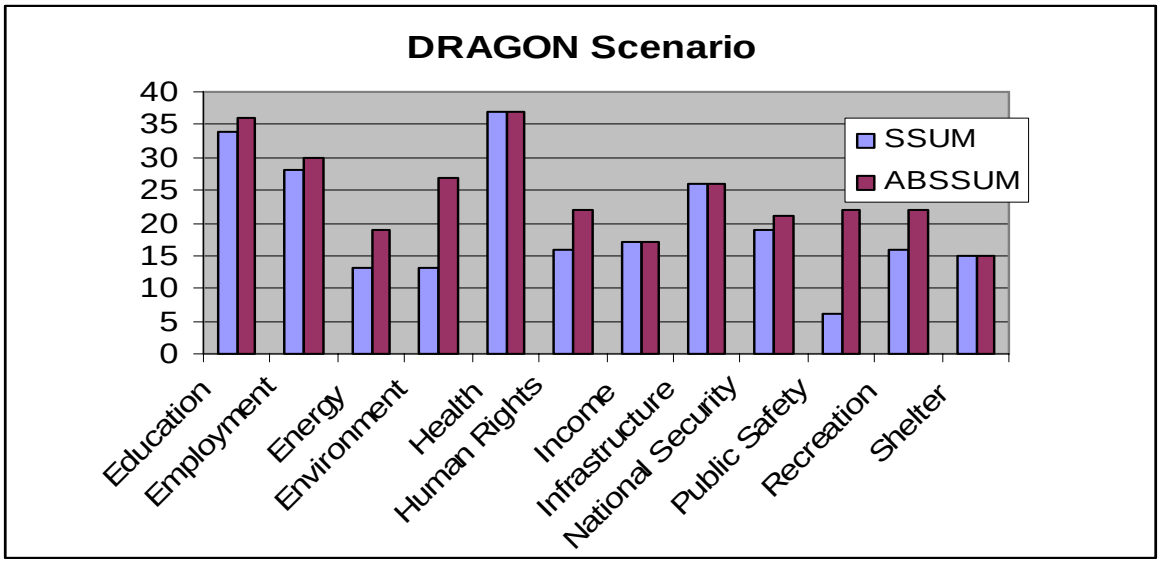
The SUM score reflected the net positive impact on the QoL from any one scenario. The ABS SUM score reflected the degree of severity of overall impact, both positive and negative.

Dragon[11]

The view of the HLEG is that convergence technologies will impact to the greatest extent (294) and in the most positive manner (240) in a future described by the Dragon scenario. Convergence technologies will have a significant and positive effect on education, health and infrastructure. They will have a varied but net moderately positive effect on energy, environment, public safety and human rights.

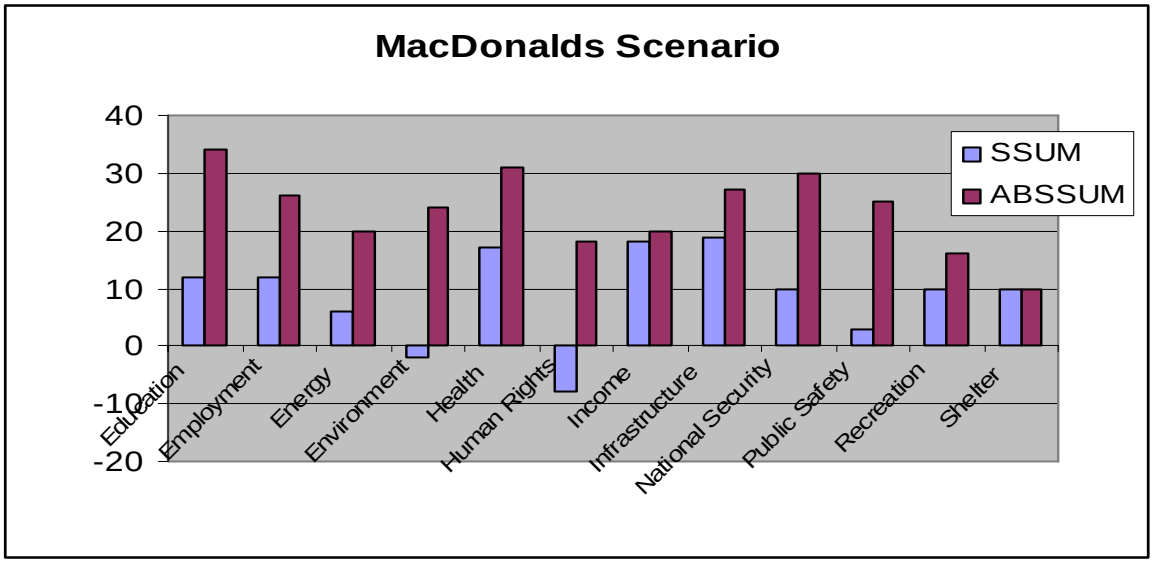
DRAGON	**SUM**	**ABSSUM**
Shelter	15	15
Income	17	17
Energy	13	19
National Sec.	19	21
Human Rights	16	22
Public Safety	6	22
Recreation	16	22
Infrastructure	26	26
Environment	13	27
Employment	28	30
Education	34	36
Health	37	37
Total	**240**	**294**

[11] **SIG 1 will continue to use the names of the Scenarios that were developed by the sub-group as in use at the time. At the time of writing, July 2nd, the final (changed names) had not been agreed on. Final recommendations and a mapping at the end of this report will reflect then new agreed names.....**



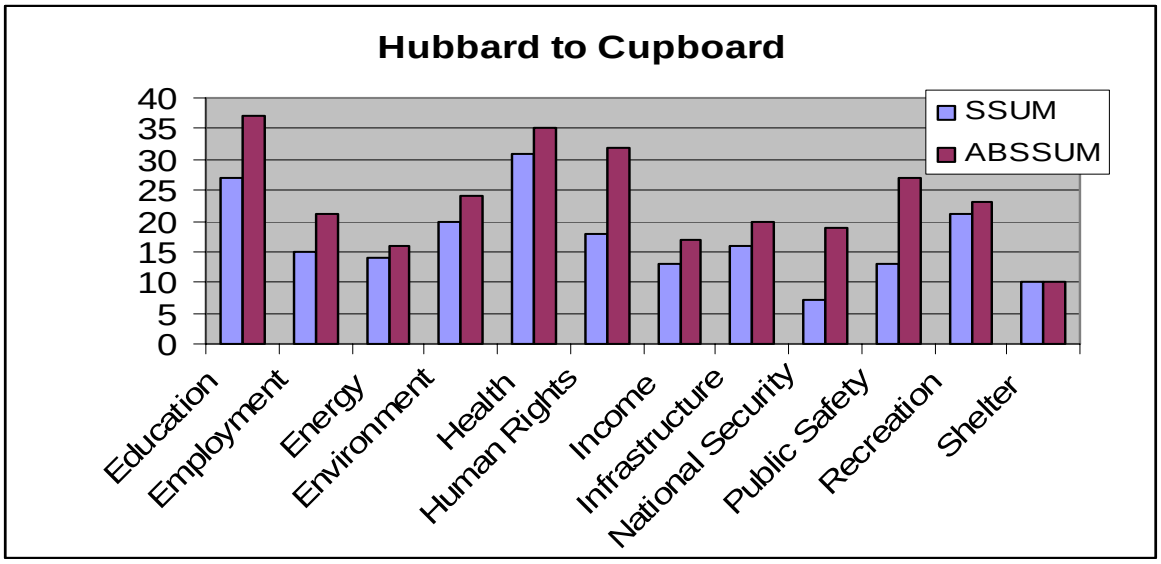
MacDonalds

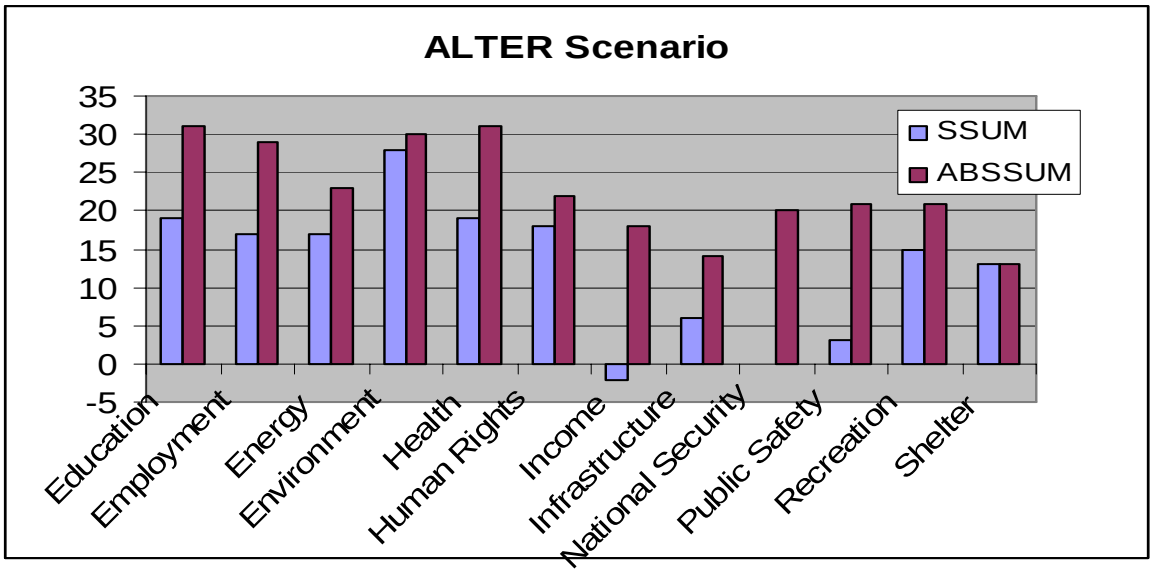
The view of the HLEG is that convergence technologies will impact to a similar extent (281) and in the most negative manner in a future described by the MacDonald's scenario. In particular, convergence technologies will have a significant and negative effect on energy, environment, public safety and human rights. They will have a varied but net moderately positive effect on education, health, and infrastructure. In short, our views on MacDonald's are a mirror image of our views on Dragon.



Hubbard and Cupboard and Alter

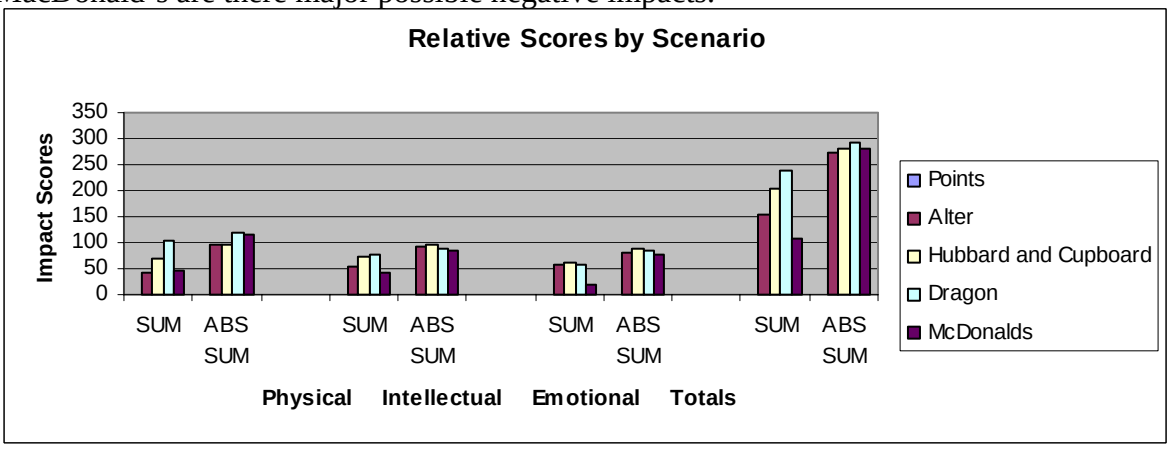
The view is that the impact of convergence technologies is potential as high under a future described by Hubbard and Cupboard, but significantly less under a future described by Alter. In either case, the effects of convergence technologies on education and health are seen as significant and positive. Equally the effects on income, infrastructure and security are seen as negative.



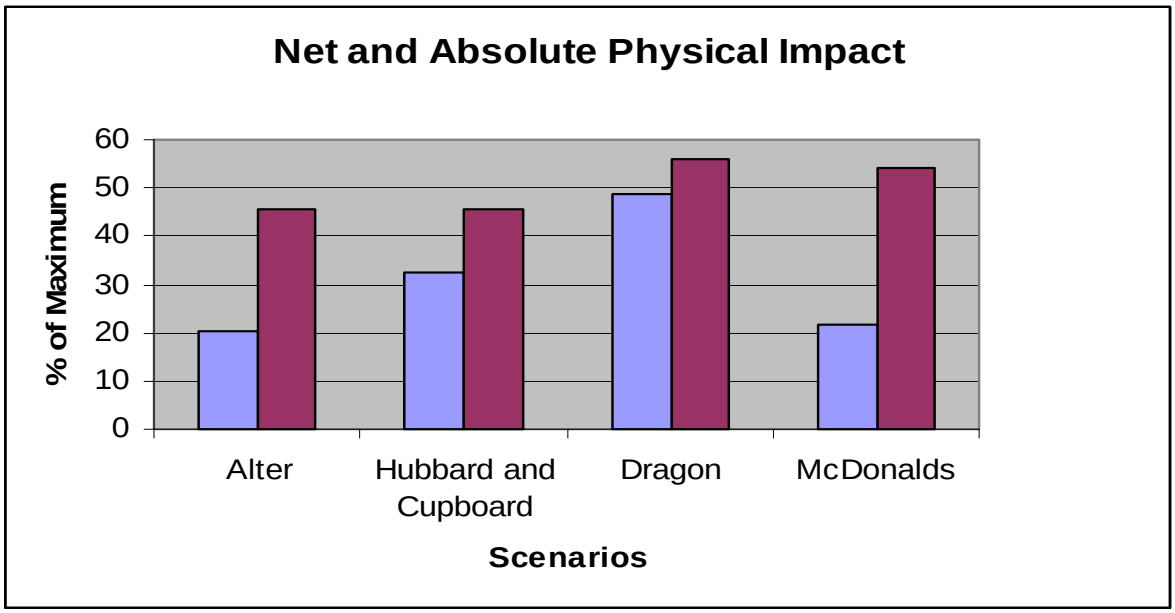


Overview

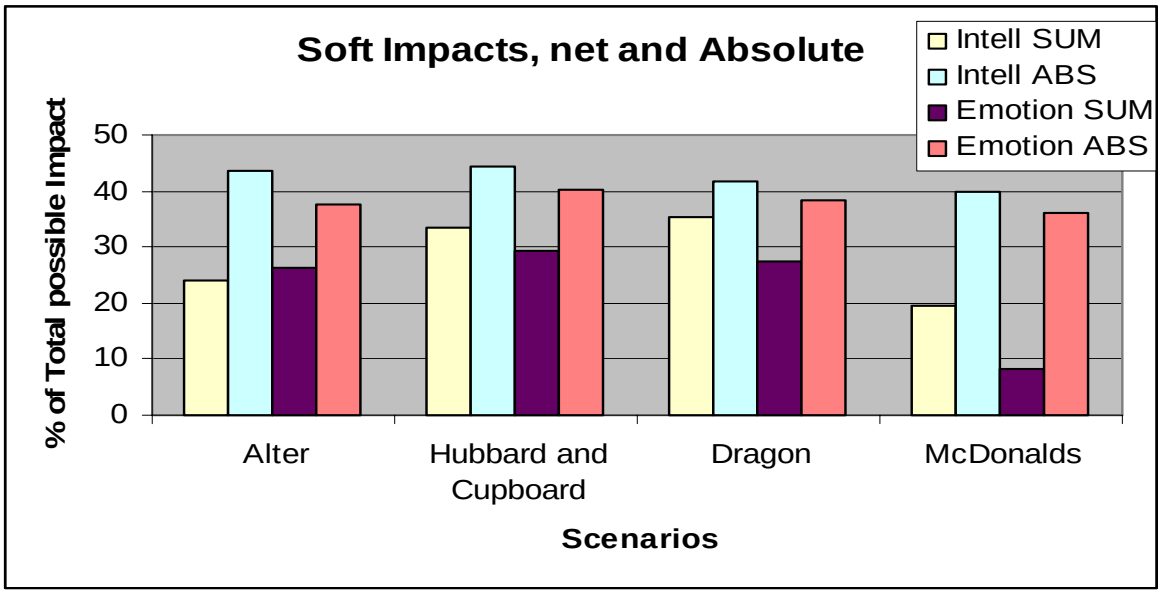
Looking at Relative scores in summation and in absolute impact terms, it seems only for MacDonald's are there major possible negative impacts.



This figure suggests Alter and MacDonald's have significant physical downsides



… which is reflected in the soft criteria too, see below.



Impact of Scenarios on QoL

The impacts can be summarised as follows. Overall, there is a very optimistic perception of the benefits of the Converging technologies on the major QoL indicators.

Dragon	**MacDonald's**	**Hubbard 2 Cupboard**	**Alter**
Impact greatest extent (294) and in the most positive manner (240) Positive effect on health (37/37), education (36/34) infrastructure (26/26). Less significant and less positive effect on environment (27/13), public safety (22/6), energy (19/13). Employment (30/28), income (17/17), individual rights (22/16) are protected.	Impact to the next greatest extent (281) and in the most negative manner (107) Significant and negative effect on public safety (25/3), environment (24/-2) energy (20/6). Significant but less positive effect on education (34/12), health (31/17), infrastructure (27/19). Employment (26/12) and income (20/18) are protected but individual rights (18/**-8**) are not.	Impact to a similar extent (281) but less negative manner (205) Significant and positive effect on education (37/27), health (35/31), public safety (27/13) and environment (24/20). Significant and positive effect on infrastructure (20/16) and energy (16/14). Individual rights (32/18), employment (21/15) income (17/13) are protected.	Impact to the least extent (273) but less negative manner (153) Significant and positive effect on health (31/19), education (31/19), environment (24/20) and energy (23/17). Significant and less positive effect on infrastructure (20/16) and energy (16/14) Very much less positive effect on public safety (21/3). Employment (29/17), individual rights (22/18) are protected but incomes (18/**-2**) are not.

Identifying Exemplar Converging Technologies

These conclusions were discussed with the HLEG in Plenary and it was agreed that the members of SIG I should concentrate their efforts on identifying specific technologies that will impact, both positively and negatively, on the following elements of the quality of an individual life:

- **Education**
- **Health**
- **Infrastructure (mainly new type information and communication)**
- **Energy**
- **Environment**
- **Public Safety.**

It should be noted that these fit well with the views that the drivers are the needs of an aging knowledge society seeking sustainable living patterns.

Technologies impacting on Key Quality of Life Indicators.

A brief questionnaire was devised and circulated to all members of the HLEG requesting their individual views on the most important technologies impacting on the QoLs. In particular they were asked only to suggest applications that were dependent on a minimum of an input from at least two of the converging technologies. The results of this exercise are presented in

two forms. A list presenting the raw data and an indication of which technologies (**N**anotechnology, **B**iotechnology**, I**nformatics, **C**ognitive Sciences) are likely to be important in its realisation and a grid that represents an assessment of the leading two technologies in a subset of the applications No judgement is made about how positive the impact might be, but in general, as with all new technological applications, care would need to be exercised to balance benefit against risk.

Application Domains and example Converging Technology Applications

Education

- Ability testing software (Toeffl type) [NIC]
- Brain doping [NBC]
- Cheap and universally available devices NBIC]
- Electronic communication in schools at different levels [NI]
- Intelligent resource acquisition in secondary and tertiary education [CI]
- Interactive games [NI]
- Mathematics visualization [NIC]
- Non-invasive behaviour control via nanoelectrodes [NBIC]
- Data storage media with very high recording densities [NI]
- Simple access to individual, telemetric knowledge [CI]
- Socialisation: learning group dynamics [CI]
- Speech recognition/translation on a mini PC for the pocket or eye [NCI]

Key: N=Nanotechnology, B=Biotechnology, I=Informatics and C=Cognitive Science

Health

- Artificial molecular muscles. [NB]
- Biosensors under the skin or ingested for diagnosis, therapeutics, prognosis and monitoring of treatment implanted [NBI]
- Biotechnology and nanotechnology in relation to spread of viruses. [NBI]
- Brain stimulation [NBC]
- Gene therapy [NB]
- Image data banks and pattern recognition [NBI]
- Intelligent artificial noses (diagnosis of disease, fast detectionof microbes}.[NBI]
- Intelligent drug delivery [NBI]
- Memory improvement and restitution, metabolic enhancement [NBC]
- Nanopumps [NB]
- Nanoelectronics record history of a specific medium [NBI]
- Prosthetic vision/hearing [NBC]
- Rationally designed drugs [NBI]
- Reproductive technologies [NB]
- Routine pre and post natal screening and diagnosis of all single gene disorders[NBI]
- Synthetic bio-compatible materials [NB]
- Synthesis of biocompatible materials (implants for bones or tissues)[NB]
- Targeted intelligent drug delivery [NBI]
- Telemedicine: monitoring, diagnosis and treatment [NBIC]

Key: N=Nanotechnology, B=Biotechnology, I=Informatics and C=Cognitive Science

Infrastructure

- Computer miniaturization (spintronics, DNA computers, molecular electronics). [NBI]
- Computer-nerve/brain interface for other than medical reasons [NBIC]
- Household robots [NIC]
- Increased information storage and calculation capacity RFID [NI]
- Integrated transport systems [NIC]
- Intelligent power grids (to avoid wholesale power-outs) [NIC]
- Optical fibre terminals [NI]
- Smart materials (sensors, actuators) for structures, in vehicles [NI]
- Ubiquitous connectivity [NI]
- Unmanned vehicles for many purposes [NI]
- Wide band Telecom WIMAX [NI]

Energy

- Biological production at low temperature, high efficiency [NIC]
- Biomimetic/hybrid bio-technical solar-energy conversion [NBI]
- Chemically driven intervention devices [NI]
- Energy saving through local sensing [NI]
- Hydrogen fuel technologies [NBI]
- Energy saving/recovery in vehicles (electric motor/generator, fuel cell ...)[NI]
- Microwave energy transmission [NI]
- Photo-voltaic devices [NI]
- Photovoltaic paint: low-cost solar cells made with nanospheres of titanium dioxide on which colouring agents are fixed. [NI]

Key: N=Nanotechnology, B=Biotechnology, I=Informatics and C=Cognitive Science

Environment

- Biologically inspired goods [BN]
- environmentally friendly decay [NB]
- Biological inspired production at low temperature, high efficiency[NBIC]
- Cities ecosystems management [NI]
- Cosmetics/ neutraceuticals [NB]
- Ecological data banks [BI]
- GIS (Geographical Information Systems) [BI]]
- Environmental monitoring (air, water) [NBI]
- Methods to clean up a polluted milieu [NB]
- 'Smart' bacteria detection [NBI]

Key: N=Nanotechnology, B=Biotechnology, I=Informatics and C=Cognitive Science

Public Safety

- Banknotes could be replaced by information [NI]
- Brain sensing: Detect bad intentions? Aggressiveness? Lying? [NIC]
- Cognitive economics and sociology for socialization of unemployed and excluded people [IC]
- Intelligent monitoring [NI]
- Monitor convicted criminals by implanted location/correction? [NBI]
- Navigation systems for all transport technologies [NI]

- Omnipresent sensors: monitor crime, fire, accident etc [NBI]
- Personal data control [NI]
- Personal defence systems [NBI]
- Personal identification systems (RFID type) [NBI]
- Sensors to struggle against biological or chemical terrorism. [NBI]
- Smart materials: detect defects, deterioration in all kinds of equipment before (catastrophic) breakdown [NI]
- Vehicles: driver oversight (intoxication; speed, distance) [NI]

Key: N=Nanotechnology, B=Biotechnology, I=Informatics and C=Cognitive Science

NBIC Application Grids

These broad areas of applications identify some key developments that may take place over the next 20 years.

Education

LeadTech-2nd Tech	**N**	**B**	**I**	**C**
N		-Brain Doping- (+C)	-Holograms - Holodecks	-Nanoelectrode signals (+B?)
B	-Direct brain interaction/interfaces		-Eco-databanks -In-touch-with-nature	-Learning Implants[in 20 years?]
I	-Micro-storage -Life books (+C)	-Interactive & Intrusive games	**-Video games**[12]	-Telemetric knowledge -Distance Learning -Speech Recognition -GIS
C	-ASINCs[13]	-Ability testers -TOEFFLs[14]	-Socialisation -Learning -Maths visualisation -Visual Recognition	

Health

LeadTec-2nd Tech	**N**	**B**	**I**	**C**
N	**- Nanoscale assembly of drug molecules** **-Nanopumps**	-Intelligent, targeted Drug Delivery -Biosensors (diagnosis prognosis, treatment) -Artificial muscles -Pre- and post natal genetic screening for all single gene disorders	-Nanosystems swarming in biosphere[as danger to health?]	-Implanted emotion sensors -Intrusive early warning systems
B	-Prosthetics Hearing (+I) -Synthetic Drugs -Bio-compatible materials -Gene therapy		-Prosthetic vision (+B) -Telemedicine) monitoring and diagnosis) -Rationally designed drugs	
I	-"Inner space" diagnostic types	-Diagnosis - Weak Signal recognition	**-Image databanks**	-Intelligent Noses (diagnosis of disease and infections)
C	-Brain imaging -Brain stimulation -Neural tracer -Behavioural modification via nanobots		-Cognitive models with consciousness	

[12] items in **BOLD on the diagonal** are generic developments in specific technologies that are seen as potentially greatly benefit that specific QoL indicator

[13] ASINC – Application Specific Invasive Nanotech Chips

[14] Test of English as a Foreign Language, but in practive applies to learning of any other language

Infrastructure (ICT focused)

LeadTech-2nd Tech	N	B	I	C
N	**-Nano storage devices**	-Computer/nerve/brain interfaces	-Spintronics -Smart materials with inbuilt sensors/actuators -Intelligent, integrated transport systems -Nanoelectronics	
B	-Bio-computers		-DNA computers	
I		-Household Droids	-Swarm systems, networks -Ubiquitous connectivity -RFID -IPv7/8	-direct brain link
C			-Telepathy	**-Intelligent systems of any sort (consciousness)**

Energy

LeadTech-2nd Tech	N	B	I	C
N	**-Nanoarray photovoltaics** **-Fusion**	-Solar paints -Biomimetic energy systems	-Chemically driven computing devices	
B		**-Hydrogen fuel**		
I	-Energy conservation systems -Microwave transmission		**-Self powered computing devices**	-Intelligent fuel saving driving
C	-Direct or stimulated energy absorbtion			-Intelligent ("conscious") eco-systems

Environment

LeadTech-2nd Tech	N	B	I	C
N	**-Assembly-reassembly**	-Neutraceuticals -Mood-cosmetics		-Cosmetics
B	-Safe Water	**-Desalination** **-Biodegradable economy** **-Sustainability**	-Customised food -Intelligent plants[15]	
I	-Groundwater micro-management -Nanoflowers, water resistant nano-wires[16]	-Intelligent sensors	**Earth Observation Systems** **Climate change**	
C			-Natural sensors (fish cells, plant cells)	**-Public Awareness** **-Public acceptance of costs**

[15] Plants that are given the ability to react to a series of stimuli or absence thereof
[16] http://news.bbc.co.uk/2/hi/science/nature/3830061.stm

Public Safety

LeadTech-2nd Tech	**N**	**B**	**I**	**C**
N	**-Ubiquitous monitoring**		-Pervasive supportive systems	-Control of instincts
B	-Brain sensing, advanced warning of intent	**-Bioterrorism**	-Omnipresent tactile and bio sensors	-Bioremediation of social dysfunction[how would that work? Biological decay of organic substance to be available as nutrients for new organism?]
I	-Intelligent Monitoring	-Bio-tagging of convicted criminals	**-Personal ID systems**	-Dematerialisation of money
C		-Personal defence systems (+I)	-Cognitive Economics	**-Socialisation of the excluded**

Drawing on these, a number of more developed feasible illustrative cases were developed to illustrate how the technologies might actually impact if they were developed as suggested. These are presented in Appendix 1

Conclusions

SIG 1, with considerable input from all members of the HLEG, has identified different sets (or clusters) of key technologies whose convergence could have a profound impact on a number of key Quality of Life indicators and thus on the citizens of Europe.

Most are perceived as positive opportunities for the economic growth of Europe and if developed within a "Dragon" scenario context would be expected to re-enforce the vision of the Lisbon Declaration and be largely beneficial.

Perceptions of the negative aspects related mainly to privacy, data integrity and such like.

Social justice, unemployment, sustainability etc. will all be influenced, in some way probably positively, but the fundamental problems are of a political/social nature and not technological, and will have to be tackled as such.