TNO-REPORT

MEGATRENDS: A BROAD OUTLOOK ON INNOVATION

TNO innovation for life

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Megatrends: a broad outlook on innovation

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Preface

This megatrends report represents one of the main features of the 'Innovation Outlook Programme' of TNO. With the Innovation Outlook programme, TNO aims to systematically and periodically identify and compare different trends in innovations in order to assess the potential impact of these innovations on society. It provides insight into the innovation dynamics in the Netherlands. The Innovation Outlook takes into account scientific, technological, economic and social dynamics regarding innovation.

The Innovation Outlook Programme started in 2007 and runs for four years. It has focused on three parallel trajectories. A forecasting text analyser tool has been developed based on state-of-the-art data-mining technologies. This tool is combined with the Dynamo database (which contains a large number of foresight studies, extracted innovation themes, societal issues as well as scientific and technological trends) and a Delphi-tool to validate the findings of the study.

In the last year of the Innovation Outlook we present the main results of the Programme in a series of reports. This report presents six megatrends that reflect the main issues that will greatly influence the western society for approximately the next fifteen years. The megatrends act as a basic reference and framework for the studies in the Innovation Outlook. This framework shapes the technological possibilities as well as possible societal, political and economic conditions and (re)actions that can influence the trajectories of their development and transformation into innovations.

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1 Executive Summary

1.1 Megatrends in a Nutshell

The term 'Megatrend' was coined by John Naisbitt in 1982 (Naisbitt, 1982) and describes a trend that is especially far reaching in regard to societal and technological changes and developments. In contrast to mere trends, megatrends are global developments that last for many decades and fulfil the following criteria:

Timeframe: at least an expected continuation for the next 15 years

'Globality': they will affect almost all world regions

Reach out: they affect society on the macro to micro level; politics, economy, science & technology, social organisations and individuals

Impact: they have a profound impact on human life and a transforming quality, i.e. they imply changes that are hard or even impossible to escape

Megatrends are an important basic analytical frame for analysing and assessing future technological and societal developments. They can be used for the improvement of strategic planning and the adjustment of business concepts and policy-making towards future developments, needs and challenges. Megatrends set up the framework that shapes the technological possibilities as well as the societal, political and economic conditions that influence the trajectories of their development and transformation into innovations.

In this outlook we will present 6 megatrends that reflect the main issues that will greatly influence society for the next 15 years at least:

1. Ageing and Fragmentation of traditional societal structures: rising life expectancy and life-style pluralisation.
2. Fading Borders: opening of geographic and societal borders and the disappearance of physical and conceptual boundaries.
3. Managing Environmental Sustainability: the rising consciousness over environmental issues drives innovation.
4. The growing concern over Risks and Security: new risks and the relevance of precaution and foresight in a complex world.
5. The Network Society: social networking, collective intelligence, web 2.0 and the internet of things.
6. The Intelligent Age: the creation of intelligent artefacts, human enhancement, converging technologies and the engineering of nature.

In contrast to other megatrend analysis, our goal is to present megatrends as a practical tool to be used for foresight exercises, the identification of innovative potentials and as an aid for policy-making. Therefore we have kept the megatrends rather broad, in the form of guidelines that can also be adjusted for specific projects and questions.

1.2 The Six Megatrends in Brief

MEGATREND 1:

Ageing and Fragmentation
of traditional societal structures,
rising life expectancy
and life-style pluralisation

Societies in Western Europe are changing, due to a number of reasons. The most important ones are demographic changes because of an increasing life-expectancy, low birth-rates (low replacement level), especially in Europe and East Asia, and high number of immigrants. Due to a lower birth rate there is a higher percentage of elderly in society, while due to a longer life expectancy this higher percentage of elderly also live longer, which is generally termed as 'ageing of society'. Because of the increasing life span, many people are expected to live longer with chronic and degenerating diseases.

On the other hand, the configuration of western societies is changing with increasing individualisation, the changing role of traditional family households and increasing plurality in norms and values. Also the inflow of many immigrants over the last decades from many different regions in the world has lead to a more diversified configuration of the population. This gave people the opportunity to get in contact with people from a wide range of cultures representing different customs, norms and values. People identify themselves less and less with only one social group, but have different relationships with different social groups, depending on the context and the activity.

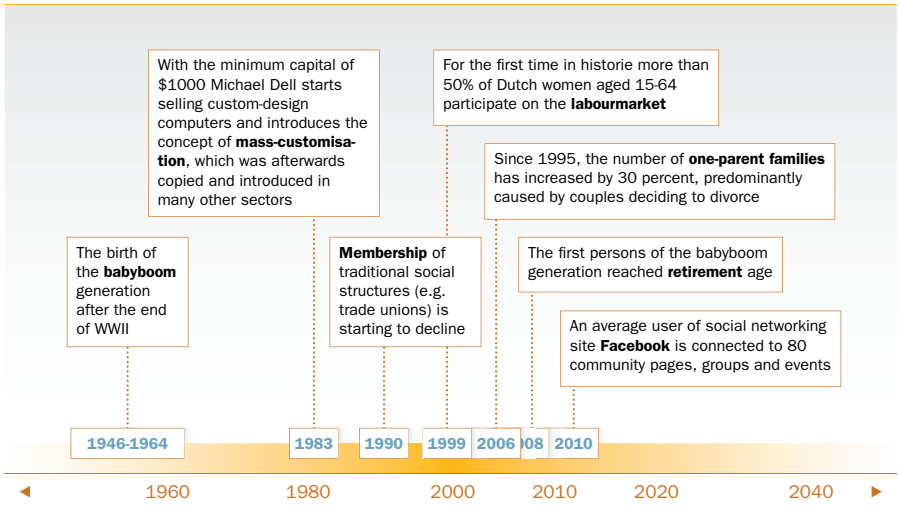
1.2.1 Evolution of Ageing and Fragmentation of traditional societal structures

The baby boom generation is about to reach retirement age, while putting a higher claim on the health care system and other social services in welfare states. The low birth-rates in western societies are expected to remain lower over time than the

replacement level, which will give a quite clear outlook of how the population pyramid in western societies will look like in 2050.

The trend of changing life-styles and the fragmentation of traditional societal structures is less clear, although a shift from long-term traditional societal structures towards more individualisation and self-chosen as well as temporary group-memberships is likely to increase. This is also supported by the possibilities and functions offered by the internet and other communication technologies, such as the social use of online networks.

FIGURE 1: Timeline with illustrating milestones in the evaluation of Ageing and Fragmentation



1.2.2 Chances for innovation

The ageing and degreening of society has numerous impacts on innovations. First, the ageing trend can involve an increase in long-term treatment and diseases that are (currently) not curable. The current health care system would not be able to adequately deal with this situation. Only new radical innovations in the healthcare system and/or medicine may overcome the lack of future employees in health care and the increasing costs of healthcare. Some solutions such as tele-care and consumer electronics for healthcare already under development lessen the financial and employment-related burdens on the care and cure system. Ageing employees (who may need more flexible working hours or other type of work), ageing customers (with different preferences), and health tourism (for elderly as well as for others) all put emphasis on different kinds of products and services.

Second, products and services are getting much more personalised; the traditional market segments for age, income and social groups are disappearing. People are combining different life-style products from different market segments and wish to obtain goods and services that are more personal in order to distinguish themselves from others. Concepts such as mass-customisation, mass-individualisation, user involvement in product-design making use of co-creation and crowdsourcing, enable the user's influence and a more user centred approach in innovation.

MEGATREND 2:

Fading Borders

opening of geographic and societal borders and the disappearance of physical and conceptual boundaries

The process of fading borders concerns the declining and blurring of geographical and conceptual borders and the decreasing limits between and within societies. This causes more interdependencies between nation states and increasing global complexity, for instance in regard to financial capital that is being reallocated all over the world. The geopolitical effects on both national economies and the global economy are tremendous, creating increasing variety and uncertainty. Underlying drivers are globalisation, migration and changing (economic and political) powers. This blurring of borders applies to different levels and patterns of change, for instance at the macro or micro level.

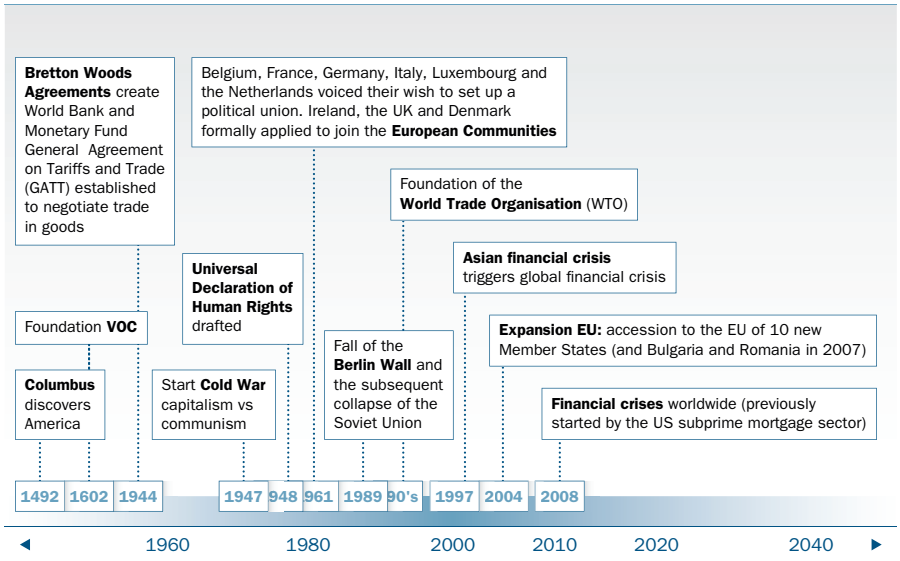
An important characteristic of this megatrend will be the fusion of cultures and systems that previously may have been strictly separated. On the other hand – which could be seen as a counter trend - cultures and systems may end up diametrically opposed to each other, as an effect of fear for identity-loss. This could reinforce differences and even bringing about serious conflicts.

1.2.3 Evolution of Fading Borders

The process of Fading Borders has been developing over a number of decades (and even centuries, as many even refer to the 'Golden Age'), but has recently reached a new phase. Technological innovations in the post-World War II period, fast interconnectivity trough modern transport, telecommunication and the access to information have been major divers for globalisation. These innovations enable real-time capital flows,

liberalisation, expansion of multinationals and foreign ownership of strategic sectors. On the other hand, they can also cause the fast global spreading of problems and crisis, such as the fear for spreading global viruses (e.g. SARS, Mexican influenza etc.). However, in many areas the more recent developments still seem to be in a relatively early stage. New technologies such as the future internet will even increase the tempo of change. The full future influence on the economic and social development process has yet to be seen. New kinds of 'warning signals' can be found in labour shifts that cause an irreversible change of social and economic structures on a global scale.

FIGURE 2: Timeline with illustrating milestones in the evaluation of Fading Borders



1.2.4 Chances for innovation

The process of Fading Borders will facilitate innovations because:

- This may create stronger international interdependencies and (gradual) transitions in social–technological systems often along with complexity and chaos. Transformations often emerge in chaos environments.
- Modern organisations create new ways of creating value to their customers and new approaches to collaboration, such as the rise of self-employment, new international business models, new types of organisations and the way we organise work and workplaces will emerge, e.g. new forms of public and private partnerships and new ways of collaboration in 'vital coalitions' being part of the civil society or strategic alliances.
- The communication market is evolving rapidly, also enabling facilities (also see megatrend 5, The Network Society).

– It may encourage innovations, looking from the perspective on innovation where diversity and avoidance of fragmentation are important indicators for success.
– It will encourage fusion and the development of hybrid products or integrated solutions.

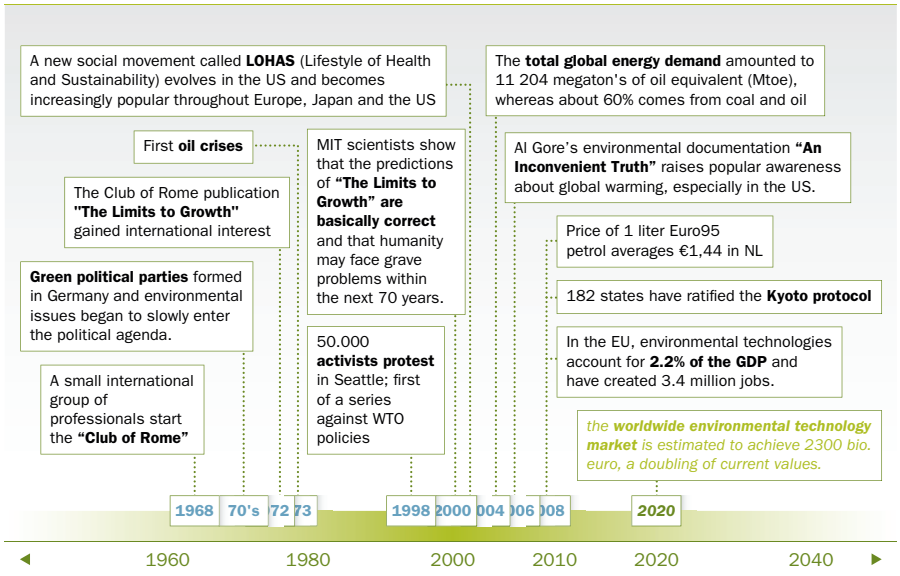
MEGATREND 3:

Managing **Environmental Sustainability**:
the rising consciousness over environmental issues drives innovation

In recent years especially the concern over the environmental dimension of sustainability has become increasingly important. According to the United Nations: ”sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (UN 1987). The growing interest in making products more environmentally friendly and energy efficient has contributed much to innovation and the development of new products and product categories. Besides the awareness concerning the supply of natural resources such as oil, this also accounts for the future scarcity of essential metal minerals (being used in e.g. electronical equipment). The wish for more environmental sustainability and the awareness that important resources will become scarce have added a new dimension to product development and processing methods. The call for more energy efficiency, alternative energies and new materials has led to new innovation potentials and the support for emerging technologies.

1.2.5 *Evolution of Environmental Sustainability issues*

FIGURE 3: Timeline with illustrating milestones in the evaluation of Environmental Sustainability



1.2.6 *Chances for innovation*

Humanity has now reached a stage of innovative and technological capacity that allows developing more sustainable products and methods of production while providing good living standards for all. Efficient renewable energy sources are under development, as well as new methods to reverse harm already done to the environment and ways to protect oneself against possible dangers.

The rising awareness over environmental problems (incl. energy) can also be seen as a chance to invest into resources and knowledge to:

- make better use of renewable energy sources
- increase energy-efficiency and think about alternative concepts of energy distribution (e.g. decentralisation)
- manufacture less harmful products
- improve production methods
- improve waste management and recycling

Europe is in particular innovative in the areas of eco-friendly construction, transport, waste management and the food and drink sector (European Commission 2008).

MEGATREND 4:

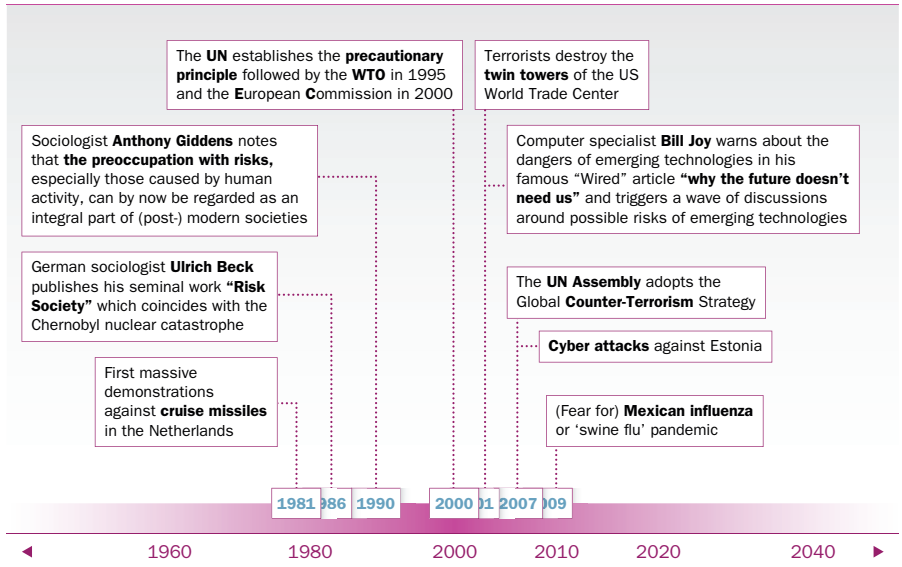
The growing concern over
Risks and Security
new risks and the relevance of precaution and foresight in a complex world

Over the past decades, especially in Europe, the notion of risks has become closely linked to the negative consequences of human technological and economic activities on health, security and the environment. Today's concerns over risks are not only about immediate threats to human life anymore (e.g. car accidents, insecure building structures and war), but also include risks to remote environments (e.g. concerns over endangered species in the Amazon), future generations (e.g. germ line therapy) or humanity as such (e.g. 'anthropotechnologies')[1]. The attitude has shifted from reaction to precaution, which is also reflected in policy-making and technology-assessment.

1 Methods employed by humans for the purpose of human (self-)domestication. Defined as: "pharmaceutical and medical products, methods and strategies with the aim of enhancing and increasing human cognitive and physical performance or capacities" (ITAS, 2008)

1.2.7 Evolution of the 'risk society'

FIGURE 4: Timeline with illustrating milestones in the evaluation of Risks and Security concerns



1.2.8 Chances for Innovation

The importance of risk issues provides incentives to develop improved solutions for old and suboptimal (e.g. pollutant, inefficient, insecure) practices and drives general developments towards a more preventative course.

This tendency can be observed in almost all industries and can lead to innovations as:

- improved safety technologies (e.g. for cars, internet applications, food testing)
- less pollutant and more sustainable solutions
- human-friendly technologies
- intelligent surveillance technology
- better privacy protection
- integration of social sciences and ethics into science and technology decision-making processes
- early detection and warning systems
- improved sensors
- preventative health care

Since innovations are by definition novelties with practical application that lack extended empirical evaluation, risk concerns over impacts of new technologies and processes could hinder the successful realisation of innovative ideas. The challenge for the future lies in finding a healthy balance between risk prevention and the courage to try new ways and innovate.

MEGATREND 5:

The Network Society

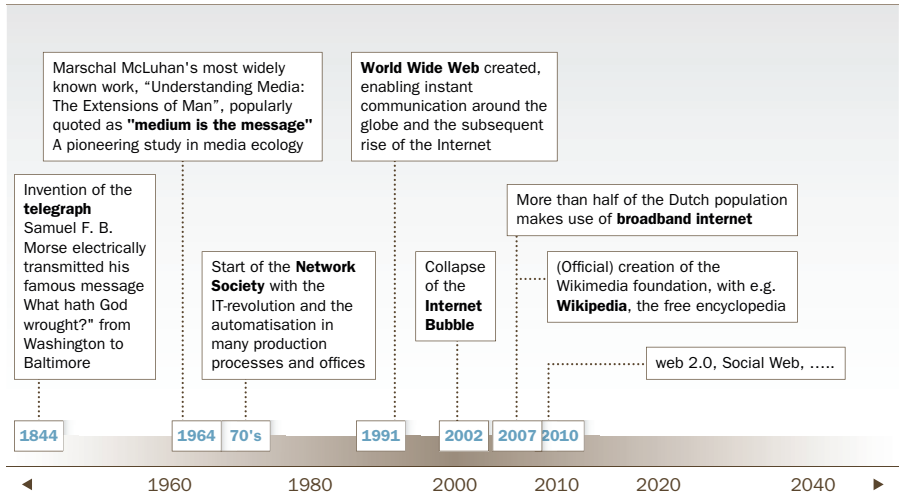
social networking, collective intelligence, web 2.0 and the internet of things

The network society is characterised by the fast utilisation of networks to gather, exchange and exploit knowledge. The impact of the utilisation of information and communication networks in all domains of society and economy is tremendous. Knowledge – in all its forms – will (and has already) become the most important factor of production. Exploiting knowledge – e.g. innovation – will become the most important asset, impacting on skills, learning capacities and societal structures.

The start of the network society can be pinpointed to the 1970s, with the information technology revolution, automatisation in offices and production processes and the subsequent rise of the Internet in the 1990s. The Network Society megatrend is expected to continue in future decades, in which the deployment of Information and Communication Technology will reach its full potential and will continue to impact and transform existing societal structures and institutions. The future phases of the network society will include an increasing integration of physical and virtual worlds, resulting in the emergence of ambient and augmented environments. The development of more intelligent mobile wireless infrastructures enable true ubiquitous as regular Web sites.

1.2.9 Evolution of the Network Society

FIGURE 5: Timeline with illustrating milestones in the evaluation of the Network Society



1.2.10 Chances for innovation

The network society enables the creation of new innovative services and the creation of new business models. The Network Society megatrend will induce new models for the innovation process itself, for conducting business, for new production processes, new services (including those provided by government and the public sector), new models of collaboration, and new models for learning and social interaction. Users will play an increasingly important role in the production and design of innovative services. The network society is also an important driver for open innovation models, in which collaboration (instead of competition) between firms is considered essential to collect and exploit knowledge that is distributed over diverse networks, e.g. to innovate.

This trend can lead to innovations such as:

- Web 2.0 and 3.0 and semantic web technologies
- Virtual- or telepresence
- New concepts for use of computers (e.g. utility computing, cloud computing)
- Virtual reality and virtual worlds
- Ubiquitous computing
- Internet of things
- Virtual agents
- ICT wearables
- Personalised media
- Virtual economy
- Experience concepts

MEGATREND 6:

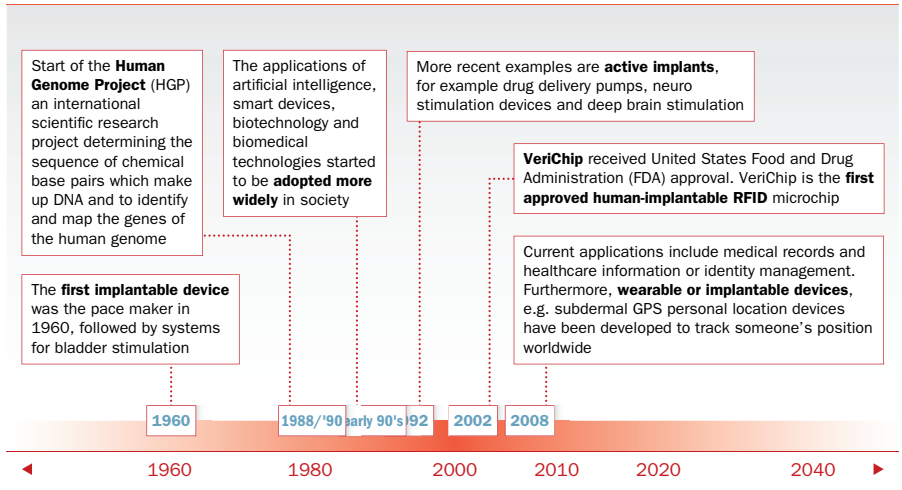
The Intelligent Age

the creation of intelligent artefacts, human enhancement, converging technologies and the engineering of nature

Intelligent technology is becoming a natural and integral element in our lives. Technological developments are connecting objects, buildings, devices and the human body with each other. With advanced developments in communication networks and infrastructures and in technologies like nanotechnology and materials science, intelligence is increasingly added to objects and devices. This will enable them to communicate with each other as well as humans and to perform increasingly difficult tasks in an autonomous way. Furthermore, technological developments will bring ICT closer to people and closer to the skin (and in fact even under the skin). These future technologies will be ubiquitous, embedded, context aware, personalised, adaptive and anticipatory.

1.2.11 Evolution of the Intelligent Age

FIGURE 6: Timeline with illustrating milestones in the evaluation of the Intelligent Age



The end of this trend will be a continuum, most likely infinite for all practical purposes (and from a purely technological perspective even irreversible). However, social resistance, influenced by techno-scepticism and/or ethical controversies (e.g. over

gene therapy or extended biomedical technologies), may slow down the development or select some paths as more likely over others.

1.2.12 Chances for innovation

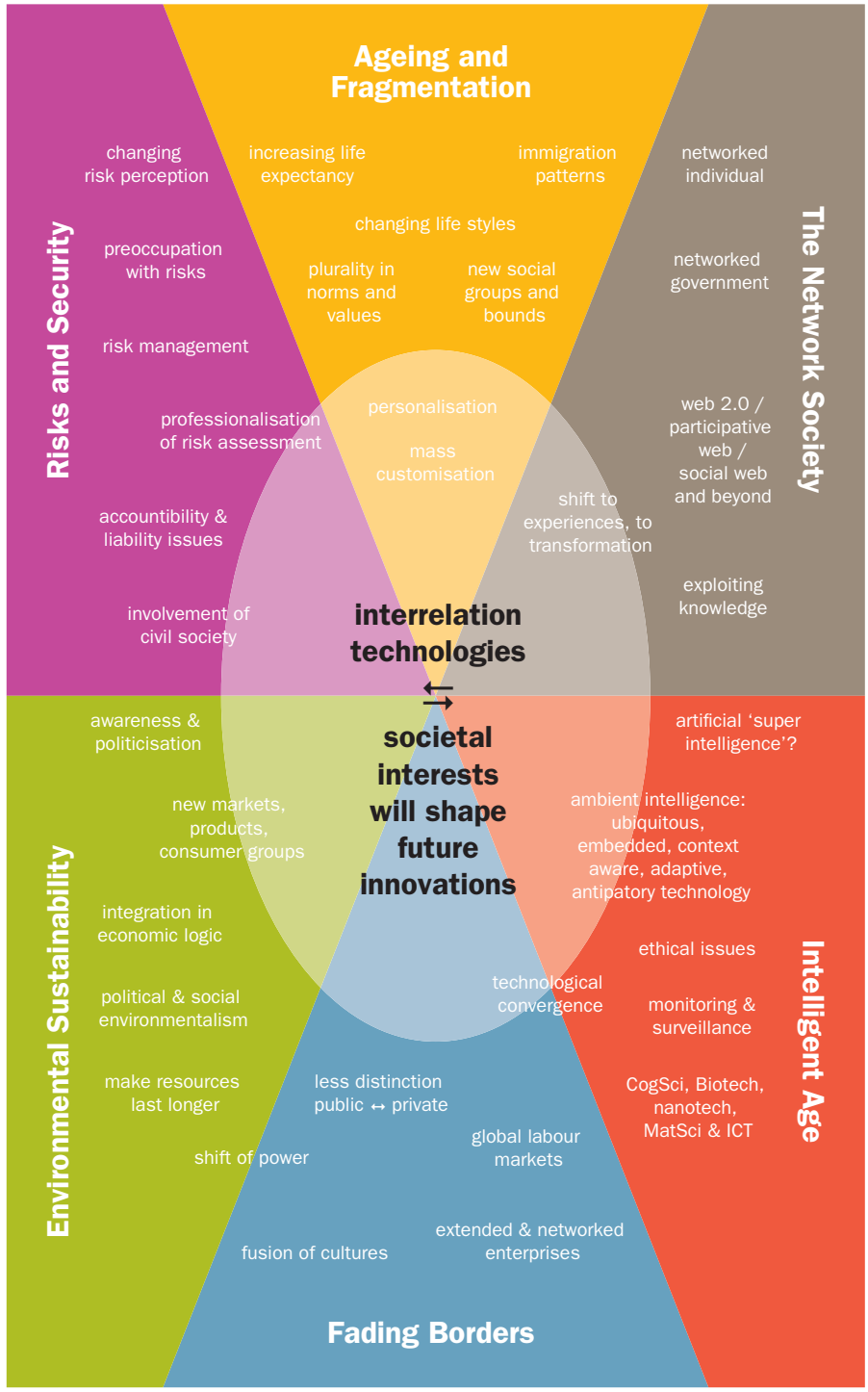
Many technological innovations are expected to derive from the research and development in converging scientific disciplines. Growth in many fields of science especially depends strongly upon the power of computers and communication infrastructures. Material sciences, modern biotechnology, neuroscience, computer technology and modern nanotechnology are innovative areas that are all closely related to and dependent on each other.

Examples of future innovation areas are:
- Advanced Artificial Intelligence and smart ICT support systems
- Domestic robots (for home use and care)
- Military robots and virtual warfare
- Neurotechnologies
- Advanced prosthetics and (cybernetic) implants
- Brain Computer Interfaces (BCI)
- Human Enhancement Technologies (HET) and nootropics[2]
- Regenerative medicine and tissue engineering
- Micro- and nanobots
- Self assembly technologies
- Synthetic organisms
- Life extension strategies

These innovations represent powerful new technological developments with potentials for profound changes. Although the developments from the pure perspective of science and engineering point towards an increasing feasibility of such developments, societal, legal and ethical concerns are high. Even advocates of such technologies that see great benefits for improving the quality of life for humanity, point out that they could bear great risks if applied in mal-intent and not within ethical and democratic framesets.

2 Nootropics (also referred to as smart drugs, memory enhancers, and cognitive enhancers) are drugs, supplements, nutraceuticals, and functional foods that are purported to improve mental functions such as cognition, memory, intelligence, motivation, attention, and concentration (http://en.wikipedia.org/wiki/Nootropic, used on Dec 1st, 2010)

FIGURE 7: Overview of major topics related to the six megatrends



2 Megatrends – an Introduction

2.1 Selection of Megatrends

Six megatrends shape the framework of TNO's Innovation Outlook Programme. The six megatrends identified as the most important issues for innovation, business and policy decision-making elaborated in this outlook are:

1. Ageing and Fragmentation of traditional societal structures: rising life expectancy and life-style pluralisation.
2. Fading Borders: opening of geographic and societal borders and the disappearance of physical and conceptual boundaries.
3. Managing Environmental Sustainability: the rising consciousness over environmental issues drives innovation.
4. The growing concern over Risks and Security: new risks and the relevance of precaution and foresight in a complex world.
5. The Network Society: social networking, collective intelligence, web 2.0 and the internet of things.
6. The Intelligent Age: the creation of intelligent artefacts, human enhancement, converging technologies and the engineering of nature.

The following selection mechanisms have been used for the identification of the six megatrends:

– Top down analysis: listing topics and long term developments, based on desk research of foresight and trend sources by leading trend authorities (e.g. Naisbitt (1982, 1990), Bakas (2005, 2006), together with an analysis of relevant technological, scientific and societal developments and key issues.

– Bottom-up analysis: a nesting analysis by integrating sub-topics and different facets[3] into larger units which are largely interrelated thus cannot be easily separated.

These megatrends set up the framework that shapes the technological possibilities as well as possible societal, political and economic conditions and (re)actions that can influence the trajectories of their development and transformation into innovations. Megatrends are not uni-dimensional, but multi-dimensional and many different developments within can be responsible for a certain outcome.

3 Also based on the societal issues and innovation themes encompassed in the TNO database 'Dynamo' (for further explanation, also see Box II).

BOX I: Megatrends are multidimensional – an example

As an example we can look at the trend of 'Ageing and Fragmentation'. Ageing with high birth rates would be less problematic for current health-care systems. High birth rates without ageing will pose other problems. Low birth rates, however, are (partly) the result of new ways of living, social liberty and individualisation (working women, emancipation, non-traditional forms of living.) Immigration may be a necessity to counter ageing plus low birth rates, but may cause new challenges and could increase social fragmentation. Hence all aspects actually form a system. Some important topics like prevention, health and communicative interconnection are actually present in every megatrend, only from different perspectives.

The framework of the six megatrends in this report contain the main technological, social and challenge-related divers (problems to be solved) that currently represent the most important issues that are also likely to remain important over the next 15 years at least.

In contrast to other megatrend analysis, the goal of this report is to present megatrends as a practical tool to be used for foresight exercises, the identification of innovative potentials and as an aid for strategic policymakers in governments or other societal / economical institutions and agencies. Therefore the megatrends are kept rather broad, in form of guidelines that can also be adjusted for specific projects and questions.

Because of their high probability of continuation, their global influence and their long duration, megatrends represent fundamental drivers that characterise current societies and will shape the global future at least for the next 15 years. Therefore the identification and analysis of megatrends is an important basis and tool for policy-making, strategic planning and business development on a mid- and long term basis.

2.2 The concept of Socio-Technical Networks

This megatrend analysis focuses on innovations within and crossing over the concept of so called 'Socio-Technical Networks' (STN). An STN consists of humans, technologies and modes of operation that function as a distinct unit to provide certain goods and services for society. Examples of STNs are traffic and transport, energy, education and healthcare (also see explanation in box II).

Within this report we have chosen to focus on ten major Socio-Technical Networks for our analysis:

1. Utilities
2. Capital market
3. Living environment
4. Quality of Life
5. Communication and information
6. Juridical system
7. Transport
8. Research & Education
9. Government
10. Defence, safety & security

The developments induced by the megatrends will lead to significant changes for the elements that make up the Socio-Technical Networks and the Socio-Technical Networks as a whole. The importance of information and their technological handling have lead to profound changes in many Socio-Technical Networks. Even the basic and manufacturing industries have experienced a shift away from labour-intensive human work to more knowledge-oriented activities, where machines work and gather data and humans control and analyse. This of course requires different skills and a higher-educated workforce. This observation also supports the prognosis already drafted by Alvin Toffler (1970), Daniel Bell (1974) and John Naisbitt (1982). If innovations are introduced in a Socio-Technical Network, its elements (technologies, people, regimes or modes of operation) will also be changed, leading to a restructuring of the whole STN. Of course a changed Socio-Technical Network may itself bring about new technological possibilities (e.g. through improved methods and materials), new problems and new societal frameworks (e.g. the network organisation), which may lead to evolutionary changes of the megatrend.

The main objective for decision-makers will be to achieve an overall improvement of the total Socio-Technical Network instead of just focusing on single aspects. This necessitates the general STN-approach of analysis.

BOX II: Explanation of Socio-Technical Networks (STN)

Socio-Technical Networks set up the framework that shapes the technological possibilities as well as the societal, political and economic conditions that influence the trajectories of their development and transformation into innovations. Society and technology cannot be looked at as two separate things but have to be viewed as an interrelated unit. If looking at important areas in society like communication and information, transportation, healthcare, energy production and distribution or defence and security, it becomes clear that these are comprised of specific technologies, people and operational modes (e.g. rules, knowledge) that work together. These systems are defined as 'Socio-Technical Systems' (abbreviated as STN).

The introduction of technological, organisational or social innovations to an STN is very likely to have an effect on the whole system. Since the objective of innovation lies in the optimisation of the whole system, it is important to take the analytical perspective of the STN-approach instead of just looking at single parts of the system or just the technological or societal side of it.

Each STN is related to a set of societal issues, such as congestion in case of traffic and transport, sustainability and efficiency in case of energy, life-long learning (education) and electronic patient files (healthcare). Dynamics of change within an STN are determined by the interplay between specific societal issues related to the STN. Societal issues are multi-layered phenomena which comprise high-level social concerns, such as an ageing population, or the creation of a sustainable living environment, which may raise issues on a lower-level of elaborations, like concerns within a specific societal constellation. Such specific questions may deal with appropriate housing and medical care for the elderly, or the economically feasible development of zero-emission vehicles for realising ecological sustainability. These examples indicate the relationship of societal issues with innovation themes, being innovation challenges on a strategic level.[4]

2.3 Theoretical Background

2.3.1 What is a Megatrend?

Megatrends are long-lasting global developments. The term 'Megatrend' was coined by John Naisbitt in 1982 and describes a trend that is especially far reaching in regard to societal and technological changes and developments.

4 The TNO database 'Dynamo' encompasses a wide range of foresight studies and trends, which is the base for a total of app. 300 innovation themes.

In contrast to mere trends, megatrends are global developments that last for the next 15 years or longer and fulfil the following criteria:

Timeframe: at least an expected continuation for the next 15 years

'Globality': they will affect almost all world regions

Reach out: they affect society on the macro to micro level; politics, economy, science & technology, social organisations and individuals

Impact: they have a profound impact on human life and a transforming quality, i.e. they imply changes that are hard or even impossible to escape

Megatrends represent highly probable future developments that are likely to profoundly shape our world during the next 15 years and beyond and thus represent a comparatively stable element within foresight. They can be said to slowly fade in and slowly fade out and develop on a rather well predictable trajectory that is likely to continue for a foreseeable time. In regard to the described megatrends, we are currently in a quite stable phase of the development curve with rather continuation to be expected than profound changes and surprises.

Nonetheless megatrends only point towards the direction of probable developments, but the future is never certain. The uncertainty of the future, however, provides humans with the possibility of actively shaping the future. Megatrends serve as an orientation point to identify probable futures, whereas alternative futures may also be possible and perhaps even more preferable.

Megatrends represent highly probable future developments that are likely to continue and profoundly shape our world during the next decade and even beyond. This is a major feature that distinguishes megatrends from so-called weak signals that are still very uncertain and hard to detect.

Megatrends are also different from trends and hypes, which may quickly change. Whereas hypes focus on one specific topic or product and through this generate unrealistic expectations, the megatrend is the lasting element behind it that remains even after a specific topic or product faded away from attention (i.e. short-termed exaggerations of a topic).

Megatrends are an important basic analytical frame for analysing and predicting technological developments as well as for planning and adjusting business concepts and policy strategies to future needs and challenges. They represent the interrelation

between technological possibilities and societal and political interests that shape the trajectories of research, development, innovations, markets and product perception.

Megatrends are not an end in itself, but a useful tool to tackle different questions, draft business strategies or develop policies. Megatrends are an important basic analytical frame for analysing and predicting technological developments, as well as for planning and adjusting business concepts and policy strategies to future needs and challenges. Foresight analysts talk about futures in the plural, which include probable, possible and preferable futures. Megatrends help with the identification and drafting of probable futures and at the same time open the mind for other possible futures, of which some might be even more preferable.

2.3.2 Three types of Megatrends

Megatrends can be divided into three categories:

1. **Technology-driven megatrends:** this category of megatrends represents the growing possibilities that are opening up through advances in science and technology. They show trajectories that are principally achievable by disregarding societal or legal concerns and constraints.
   They include developments like the further miniaturisation and speed increase of microprocessors and computing devices, growing technological networking capabilities, the ability to manipulate objects on the nanometre scale, the growing knowledge about biological systems on the molecular level and about the human brain and related technological applications.

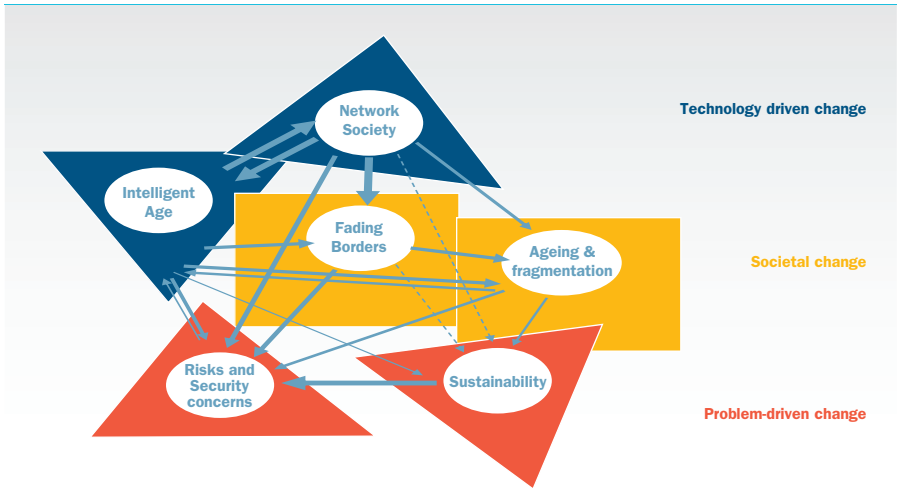
2. **Societal megatrends:** this category of megatrends represents societal changes and attitudes that are very likely to continue over the next decade and beyond. They can have a profound influence on the demand for products, technologies and innovations. Examples are demographic developments like increasing life expectancy (ageing), a decline in the number of children in most European countries, the diversification of lifestyles, growing individualisation and globalisation. Although these are social developments, parts of it are also rooted in technological developments like ICT or improvements in medicine. Societal developments can also lead to counter-reactions, which at the beginning may not have enough impact to change the megatrend. But over time they could become increasingly influential on further developments.

3. **Problem-driven megatrends**: these megatrends represent pressing problems that humanity is currently facing and for which the finding of solutions represents a high priority. Therefore it is likely that such pressing problems will guide the selection of technological developments and innovations towards those that show especially promising in this context. Major examples for current problem-driven megatrends

are the importance of environmental sustainability and growing concern over risk and security issues that are getting increasingly important in the context of scientific research and technological development.

Figure 8 shows these three categories of the megatrends, based on the origin of their development and their focus areas as described. The arrows in this figure represent the many relations and influencing factors between the trends.

FIGURE 8: Interrelations of the six megatrends



2.3.3 *The mutual influence of society and technology*

In principle technology is only constrained by natural laws. The current human theoretical scientific knowledge very likely only represents a tiny fraction of what could be principally known. Nonetheless human knowledge and theories are constantly expanding and it is very hard to make existing knowledge unknown again.

The transformation of theoretical knowledge into real technical applications necessitates certain technologies like computers, microscopes, filters, machines etc., which themselves are the product of scientific analysis and theories. If the world would be a computer simulation (and if we new it), then experiments and innovations could be realised rather fast, because they would not present any risk and would be reversible. This means that besides constraints by natural laws and resources, society as such is a great selector for which ideas and developments are likely to be realised and which not. There are pressing problems to be solved which put priorities towards research and development, e.g. to improve renewable energy resources and to improve energy

efficiency. And there social concerns that may make some technologically possible developments undesirable, e.g. genetically engineered human-animal chimera.

2.3.4 Megatrend hierarchy

It seems that there exists a hierarchy within the identified megatrends. This understanding could be useful for foresight and technology analysis. 'Risks & Security' as well as 'Environmental Sustainability' can be said to represent important governing principles. Especially the growing concern over risk and security issues is very multidimensional and encompasses topics ranging from fears about terrorism, over quality control of products and social security questions to new ethical considerations about emerging technologies. Thus considerations about risk minimisation, potential harms and environmental concerns are largely influencing the development and priority setting in research and development.

Currently, the importance of sustainability with a great emphasis on the ecological dimension as well as a growing concern over risk and safety issues, make it likely that certain technologies will be favoured over others. The question is how societies will react when a suggested solution to a problem (i.e. age-related diseases) is a controversial technology (like human embryonic stem cell research, neurotechnology or the use of nootropics).

It seems that practical prospects may overrule theoretical and ethical concerns. If looking at human embryonic stem cell research, for example, the global tendency goes towards more liberal policies (partly associated to life-style pluralisation) with more than half of the world's population today holding a permissible or flexible stance[5]. A global reversal of this trend may be difficult to implement. In regard to scientific and technological progress it is hard to establish global restrictions and controls (Fading Borders). Therefore, if the knowledge and the means are there and if there is not a societal consensus about its prohibition, more liberal and profitable stances may win out over the longer run.

5 http://mbbnet.umn.edu/scmap.html

2.4 Structure of this report

Each megatrend will be described and analysed in a separate chapter. The megatrend analysis will be provided alongside the following sections:

1. A **description and definition** of the megatrend

2. **Link with innovations** - stating the relevance of the megatrend for innovation, e.g. major changes in society, the innovation process, or innovative concepts.

3. **Impact** - the influence on (future) society and daily life. For each trend a radar figure is added, based on an assessment of the impact of the specific trend in the ten different Social Technical Networks (STN's). Also see Box II and Annex 1.

4. **Background analysis** - with topics, issues, meanings etc. closely connected with the trend.

5. **Counter-developments** - developments and tendencies in an opposite direction that may influence the trend or the tempo of a process of change.

BOX III: The meaning of 'countertrends' and 'counter developments'

Countertrends are defined as forces that may influence the trajectory, further development or speed of a megatrend. Although the term 'countertrend' seems to contradict the definition of a megatrend - which is expected to continue for more than a decade into the future - the existence of a counter-trend can actually be regarded as proof for the relevance of a megatrend. Since every idea and development that is perceived as serious and important provokes concerns and resistance, the existence of counter movements serves as an indicator that the issue is important.

For example, the existence of 'anti-globalisation activists' shows that globalisation is in fact an issue that people consider important and people expect to continue. Whereas it is unlikely that countertrends will totally eliminate a megatrend within a short period of time, resistance and criticism often provide important inputs for innovation and a reshaping of a megatrend trajectory. Thus it may be more useful to speak of 'counter-developments' than of 'counter-trends'
In a way, the megatrends 'Environmental Sustainability' and 'Risks and Security' can be regarded as a countertrend or at least a means of checks and balances for the 'Intelligent Age' and the 'Network society' megatrends. Although they are not likely to bring the intelligent age or network society to a fall, they may lead them towards new directions like the improvement of internet security, green ICT or the drafting of a European-specific solution for converging technology issues (HLEG 2004).

MEGATREND

CHAPTER 3

AGEING AND FRAGMENTATION

The ageing and fragmentation of traditional social structures will change the configuration of western societies due to rising life expectancy and life-style pluralisation.

3.1 Ageing in western societies

Societies in Western Europe are changing due to a number of reasons. The most important ones are demographic changes due to an increase in life-expectancy, low birth-rates (which results in a low replacement level, especially in Europe and East Asia), and migration. As larger shares of society are getting older, more and more people are likely to become prone to age-related and degenerative diseases (e.g. Diabetes, Alzheimer and rheumatic disorders, see Balducci 2004). Their care and financial security (pensions) requires human and financial resources that have to be shouldered by a decreasing number of people due to low birth rates and the declining proportion of the working population.

Some dimensions of this trend are likely to continue at least within the next 15 years. The life expectancy in Europe and other post-industrialised countries will continue to remain high and even increase. The trend of ageing will reach its highest impact in future decades when the high peak of population born around 1960 will reach retirement age (see Figure 11).

This can lead to an increase in older employees who wish to continue working beyond official retirement age, but also to a larger number of people who may not be able to live independently without the help of others due to age-related illnesses. Both trajectories require societal adaptations, ether in regard to work-biographies and education and training or in regard to structuring social security systems.

Even if the birth rate would increase significantly, it would take time until positive effects (e.g. in regard to social security financing) will show. Migration could compensate for problematic changes in regard to age distributions, but the number of immigrants in European countries has slowed down, partly due to stricter immigration laws.

BOX IV: The impact of the individualisation trend

The megatrend of ageing is easily recognisable in the demographic statistics, just like the low birth-rate and the amount of immigrants. Individualisation, changing households and life style are not new trends and have been spotted already for some time. The impact of the individualisation trend and the increasing plurality in values and norms and life-style on innovations have been noticed in the late 1990s in the increasing demand for more personalised (consumer) products and the use of these products in making a statement about one's identity.

3.2 Fragmentation and life-style changes

The configuration of western societies is also changing due to increasing individualisation, the influence of immigrants, a changing role of traditional family households and a diversification in norms and values. People identify themselves less and less with only one social group, but have - depending on the context and the activity - different relationships with a variety of social groups.

The internet and virtual worlds allow for the experimentation with multiple identities and technology even enables physical identity-changes through plastic surgery or sex-reassignment surgery (transgenderism).

The trend of individualisation continues, although another trend for a search of 'sense of belonging' is emerging and can be observed in the growth of some traditional religions, the increasing interest in spiritual literature and activities such as New Age, Buddhism, self-actualisation et cetera, which creates new social groups and bounds (see for example Jain, A.K et al. 2002). But 'identity' has become more something that is being actively constructed and chosen than something that is considered as a 'given' based on birth and tradition.

3.3 Link of the 'Ageing and Fragmentation' megatrend with innovations

3.3.1 Organisational and medical innovations for the aging society

The ageing combined with degreening (due to lower birth rates) of society has numerous impacts on innovations. First, ageing could in fact lead to a high number of people with long-term, non-curable diseases, thus necessitating more intensive and extensive health care that poses huge challenges for the current health care systems. Ageing employees (who might need more flexible working hours and other types of work), ageing customers (with different preferences), and health tourism[6] (for elderly as well as for others) represent demographic factors that have an impact on markets, economies, products and services.

Only new radical innovations in medicine and/or the healthcare system may overcome the lack of future employees and financial resources in health care. Current proposals for tackling the system focus on three dimensions. The first one deals with changes in the organisational structure of social and healthcare systems and focuses on efficiency, cost reductions and changes in regard to the retirement age and pension

6 Medical tourism (also called medical travel, health tourism or global healthcare) is a term to describe the practice of travelling across international borders to obtain health care.

financing schemes. The second dimension focuses on assisting and supporting technologies for the elderly to reduce their need for external help (to support independent living for as long as possible). Developments include tele-health, health monitoring, smart living, Ambient Assisted Living, even making use of care robots. The third way may be the most ambitious and aims at the roots of the problem. It includes research and development activities to find cures for dementia and age-related diseases, regenerative medicine and possibly even methods to slow down the aging process altogether.

3.3.2 Innovations for changing life-styles

The increasing individualisation also affects the demand for products, the interest in customisation and organisational structures developing towards less hierarchical systems. Furthermore in many western European countries, work is not seen as a source of income alone, but also as a meaningful way to spent time, which is also being increasingly considered by employers.

Technological possibilities like digitisation as well as general cost reductions of ICT can be regarded as important enablers for the realisation of customisation and individualisation. Rapid prototyping, for example, allows for the individualised production of items by everyone and the technology is getting better as well as cheaper. Mass customisation has been introduced as a way to enable the efficient and mass production of individualised goods, e.g. through modular design. But individualisation is not only about consumer goods but also about services and even medical treatments like personalised medicine, which can be even built upon open-source ideologies[7].

All these developments have an impact on the way products and services are being produced, bought and consumed as well as on the nature of these products and services. Products and services are getting much more personalised and many traditional product categorisations along the lines of age, income and social group are disappearing. People are combining different life-style products from different market segments and are interested in choosing goods and services that are more personalised in order to actualise and distinguish themselves from other people. New concepts such as mass-customisation, mass-individualisation, and user involvement in product-design as well as the Do-It-Yourself movement represent different facets of user centred innovations.

7 http://pinkarmy.org/

BOX V – Examples of changing life-styles and innovations

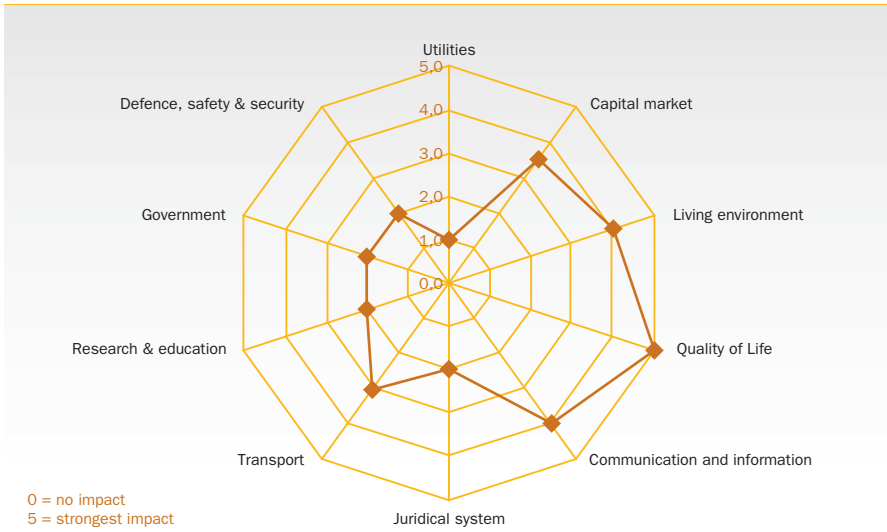
Some of the changing life-styles can be noticed in the development of new trends in innovations, for example the mass-customisation, personalised foods, media and medicine. Also the changing life-style and different non-traditional way in which people communicate and do business has lead to new forms of partnerships and organisational structures, like public private partnerships, virtual organisations or online communities.

3.4 Impact of the 'Ageing and Fragmentation' megatrend

The changes in demography and changing social structures in society have an impact on all levels of society and on the daily life of all citizens. Customers and employees are ageing, life-styles are becoming more diversified and people value the possibilities of individualisation and free choices as social pressures and norms are fading. This is asking for different work and learning biographies, products and services. The pressure on the healthcare system and pension system will continue to increase and is calling for innovative solutions.

More attention is paid to the rights of the individual (for example the right for a smoking free working or dining environment, or the right to equal opportunities and income). Changes in norms and values in society, accompanied by the increasing plurality in norms and values, have led and will continue to lead to an increasing demand for customisation and individualisation of products, goods and services. But also to new communications and organisational structures in work or school environments. More flexibility at the workplace and a more individualised education are already under way in some cases.

FIGURE 9: Impact analysis of megatrend Ageing and Fragmentation on different Socio-Technical Networks



In general as can be seen in figure 9:

The impact of the megatrend is the largest on the Quality of Life Socio-Technical Network (STN), including healthcare, pension funding etc. There is also quite some impact on the STN Living environment, which includes the high amount of one-person households and one-parent household, as well as the housing and public housing of elderly.

The impact of the megatrend on the Capital market (pension funds) and Communication and Information (individuals communicate due to individualisation with different people in different ways and social groups have different structures) is also quite high.

BOX VI: A sample of innovations related to Ageing and Fragmentation of traditional societal structures:

– Health tourism
– Effective medicines
– Personalized care (personalized health systems)
– Consumer electronics for healthcare
– Preventive health care
– Early diagnostics
– Nursing aids
– Targeted drug treatment
– e-health
– Personalised media
– Life-long education and training
– Health care robots
– Surgical robots
– Social networking
– Virtual economy
– Experience concepts
– Mass customization
– Telecommuting
– Convenience concepts
– e-democracy
– Interactive decision management
– e-government
– Medicinal foods
– Personalized products and services (e.g. medicine, food, education)
– Home automation

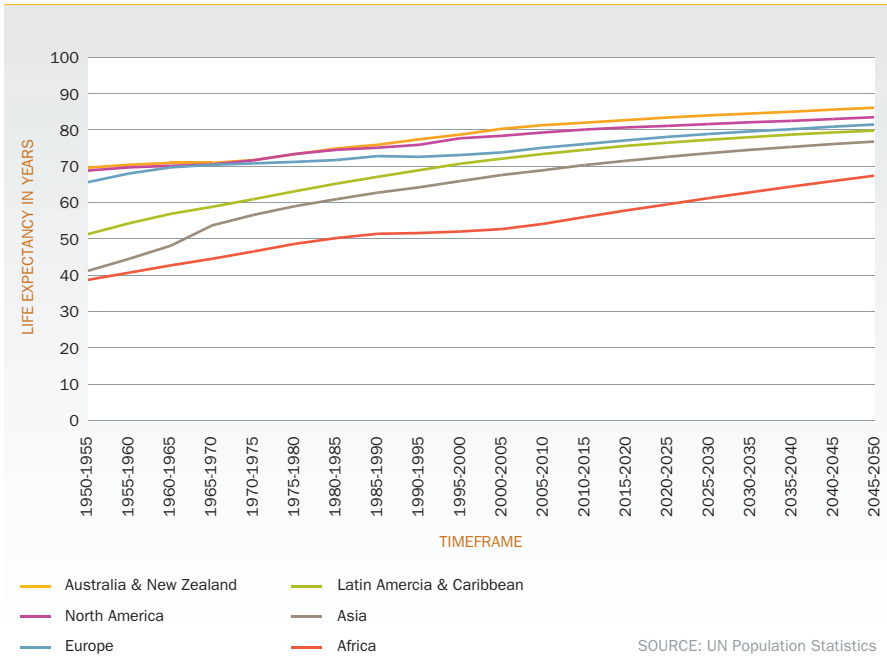
3.5 Background analysis of the 'Ageing and Fragmentation' megatrend

3.5.1 The effects of rising life expectancy

The 'Ageing and Fragmentation' megatrend combines several interlinked trends, which affect the structure of western societies. Important are the demographic changes, which are restructuring society.

One important trend that especially affects post-industrialised countries is the rising life-expectancy of people (see Figure 10). Although this is actually a positive development, it could turn out to be quite problematic if it leads to a longer time of (age-related) illness. If people grow older, but at the same time are not able to work longer due to health problems, this will put a stress on pension funds and health insurance systems. In many Western societies this situation is even amplified by declining birth-rates.

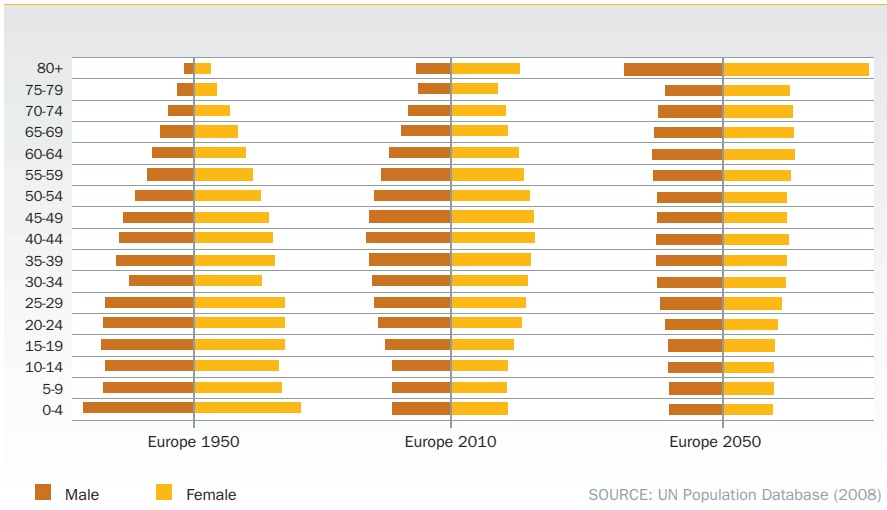
FIGURE 10: Life Expectancy at Birth (1950-2050)



Because of the expected negative effects on social security systems, efforts are increasing to counter age-related diseases. Finding cures for dementia and other age-related diseases is developing into an important topic for medical and biological research and even engineering (e.g. in the field of robotics, especially in Asia). Gerontology (the scientific study of aging) and even biogerontology (the scientific study of the biological mechanisms of ageing) are becoming increasingly established. The main objective of the efforts is an extension of the healthy life span, enabling people to enjoy a longer part of their lives in good health and even work longer, thus taking a burden off social security and insurance systems.

If medical solutions will not be effective, a shortage of caring-personnel is expected. Also the ageing of the baby-boomers who are now beginning to reach the retirement age, combined with a decrease in birth rates in Europe over the last decades, puts additional stress on the system. These elderly put a higher claim on pension funding and health care funding, since on average they are inactive on the labour market and their probability of needing long-term care and assistance rises.

FIGURE 11: Age pyramids for EU-25 population, 1950, 2010, 2050

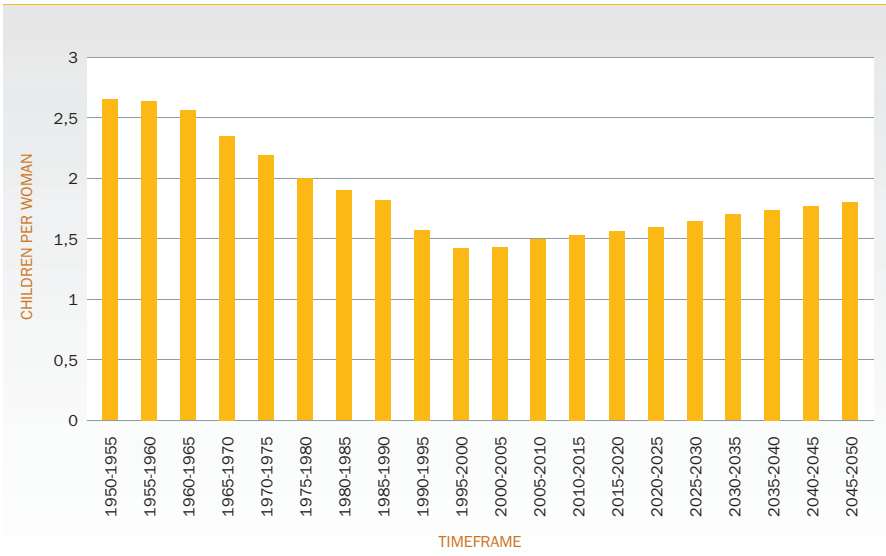


SOURCE: UN Population Database (2008)

The costs of health care are growing in many countries, while the shortage of employees in the health-care sector is also likely to continue to grow. This asks for a new better and more efficient health-care system, with innovations that assist care personnel or make it possible for elderly to continue living at home longer. Also the cure system asks for more efficient innovations to shorten the waiting lists of patients for operations and diagnosis of specialised doctors.

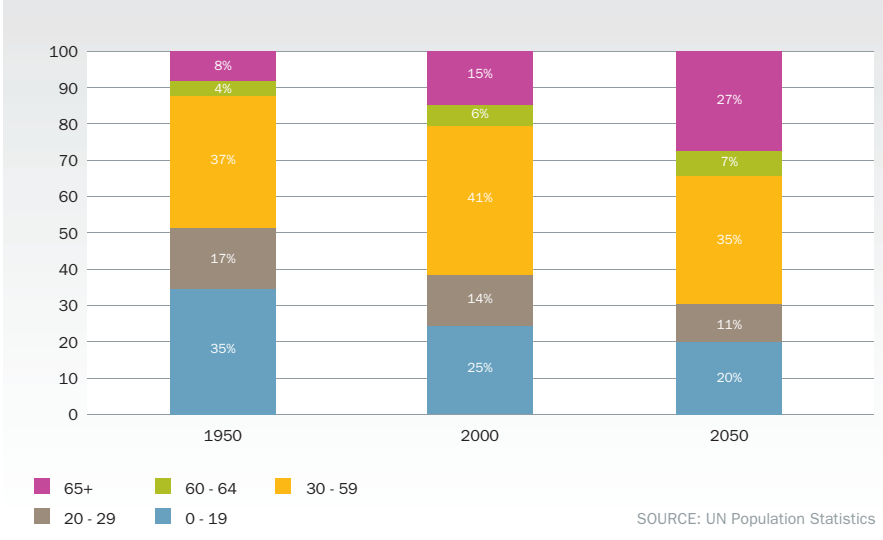
Also there are less young people, because of low-birth rates over a long period, which in many western European countries is below the replacement rate.

FIGURE 12: Fertility in Europe 1950 – 2050



SOURCE: UN Population Statistics

FIGURE 13: Age-range Distribution (Europe 1950, 2000, 2050



SOURCE: UN Population Statistics

The share of non-employed people compared to the working population is increasing in European Countries. In working life the retirement of many elderly employees in companies means the loss of much knowledge and experience, while there are not enough young people to replace all these positions.

New innovative solutions to keep the knowledge and experience available for the company, for example in new contract forms for older employees, will be necessary. Many elderly often appreciate to continue sharing their knowledge and experience in a more flexible labour contract. Flexible working times and later retirement, new forms of health care funding and management as well as ways to improve the participation of elderly on the labour market and different solutions for pension funding could be named as possible ideas.

While some countries try to solve the problem of potential labour shortages through immigration, others like Japan or South Korea are already envisioning high-tech solution via home/care robots, telemedicine/e-health and home automation. All scenarios around demographic change are hard to reverse on a natural basis and in an ethically acceptable manner and thus will greatly impact the socio-cultural frame of future post-industrialised countries, either through health-span extension, stress on social security and care-personnel, immigration or robotisation. The expected developments and potential problems associated with aging also put more emphasis medicine and healthcare in a scientific-technological and societal context.

However, elderly people, especially those who are financially well off, create a new markets, e.g. for health tourism, health and wellness products and services, recreation and new product and services especially customised for elderly. Some of these can be related to care and cure, but despite growing problems, the number of healthy and active elderly is also increasing. This latter category of customers generally does not want products and services that are branded for 'elderly', but wishes for products and services that are suitable for their life-style.

3.5.2 Increasing individualisation leading to new social structures

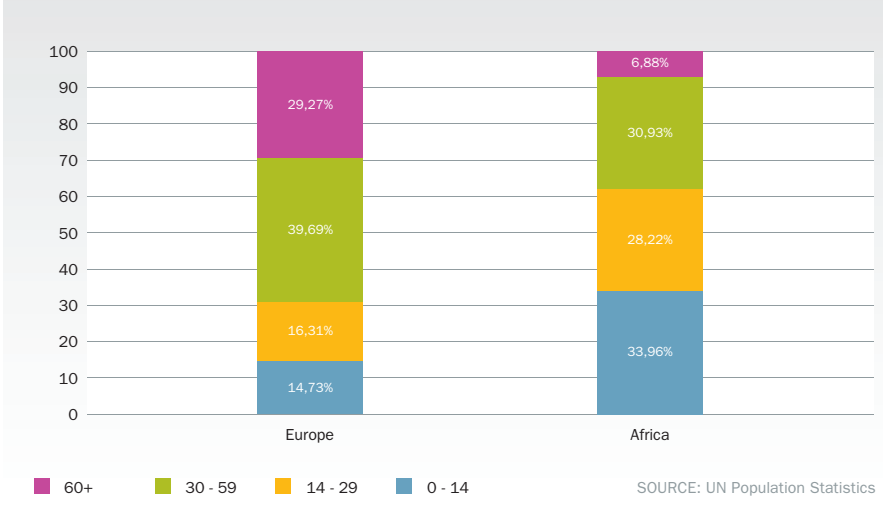
Another trend which affects society is the higher number of smaller households and an increasing individualisation leading to new social structures. The traditional family life is not as dominant as it used to be and more single person households occur. This trend is linked to the increasing individualisation which has changed western societies over the last decades and still raises issues and new changes in the daily life of citizens and consumers. Also the changing role of woman continuous to shape society and the individualisation and decrease of importance of traditional strong social groups (church, ethnic groups, etc) is fostering the increasing plurality of norms and values in society.

All these changes in society are also changing the daily life style of people and affecting their behaviour in the way they live, the products and services they buy, the way they communicate etc. This is also affecting the way business innovates and markets new products and services. This has also lead to the trend of the disappearance of traditional market segments in terms of income, age, social group.

3.5.3 *Changing populations*

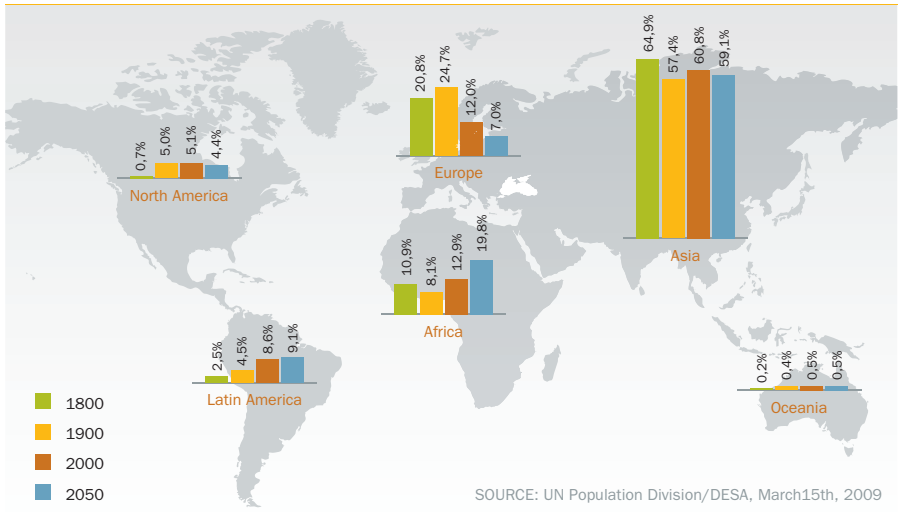
The ageing post-industrial countries will see emerging and developing societies that are dominated by young people. The local and global distribution of age-classes and nationalities will undergo profound changes within the next decade and beyond, thus affecting social security systems, the economy and cultural settings. In 2030 app. 28% of Africans will be in the age range between 14 and 29 years, whereas in Europe it will only be app. 16%.

FIGURE 14: Comparison of Age Distribution between Europe and Africa in 2030



For the last decades (since World War II), the world population multiplied rapidly. As figure 15 shows, the major share of the future annual growth of the global population will occur in the less developed countries in Africa, Asia, and Latin America, whose population growth rates are much higher than in the more developed countries in Europe, North America and Oceania. The overall effects of this growth on living standards, resource use and the environment will continue to change the world landscape.

FIGURE 15: World Population Distribution by Region, 1800–2050



3.5.4 *Individualisation, life-style pluralisation and the new role of women*

As traditional social structures have lost much of their influence, individuality has become increasingly important and even more relevant. This has positive as well as negative sides. On the positive side it gives more freedom to the individual. On the negative side, a lack of orientation could be confusing and stressful (cf. Elias 2001). This dilemma may be reflected in the observation that many people are not total individuals but organise in social groups of their own choice, based on interests (e.g. NGOs), religion (e.g. Christian or Islamic communities) or ethnicity (e.g. foreign ethnic communities). In most post-industrialised countries social coercion in regard to an adult's life-choices (e.g. marriage, religion, world views) is generally absent, which leads to the sometimes difficult necessity of making ones own choices.

3.5.5 *Technology and individualisation*

Technology is also supporting the process of individualisation. The prime example is virtual worlds, in which individuals can create their own avatar, i.e. their personal distinct visual representation on the internet. But also simple things like the freedom of choice in regard to one's user names and e-mail-addresses provide opportunities to play with individuality and even multiple identities. Virtual worlds allow for playful experimentation with the concept of 'morphological freedom' (i.e. the personal right of

body modification)[8]. But modern technology even allows for 'physiological customisation' ranging from artificial hair colouring and coloured contact lenses over plastic surgery to gender-rearrangement surgery. Genetic technologies could one day even provide at least the principal possibility of genetic modification or 'designer babies', although society may opt against such developments due to ethical considerations.

In real everyday life, products and goods can already be individually designed and created at affordable prices. The internet enables people to send individual designs for customised production in an efficient manner and technologies like rapid prototyping allow for a 3-D realisation of individual designs. On an industrial scale, methods like mass customisation that often build on modular designs represent a compromise between mass fabrication and individual design. In general, products will be more personalised and emerging sciences and technologies are likely to allow for products like personalised medicine or personalised foods in the future. The tendency to individualisation and personal freedom is also leading to changes in employment setting with more emphasis on personal initiative, creativity and less hierarchical structures. This is especially pronounced in the software and ICT industry, but is likely to spill over to other areas, especially in regard to knowledge-based work.

3.6 Counter-developments for ageing and fragmentation

3.6.1 Life-span decreases through unhealthy life-styles

Countermeasures against an ageing population, like an increasing birth-rate, take much time to have an impact on all effects of an ageing society, and cannot undo all the effects of an ageing society. The birth rate in western societies seems to continue to decline and won't be a countertrend for the ageing population in western societies (see UN data). But there are also concerns about a possibly decrease in life-expectancy, due to unhealthy life-styles and related consequences such as obesity and illnesses like type-II diabetes and cardio-vascular problems. This would put even greater stress on social security and healthcare systems, since it leads to an additional decline of productive workers and an additional increase in health care costs. Although scientists are in search for breakthroughs in life extending medicine, obesity and related health problems could even reduce life-expectancy. Some even fear that parents may outlive their children due to such problems[9].

8 Interestingly the practice of body modification can also have dual aspects. On one hand it can denote the highest degree of individuality, whereas on the other such practices are often used to express the belonging to a certain group.

9 http://www.medicinenet.com/script/main/art.asp?articlekey=115204

3.6.2 Group identities and collective intelligence

The continuing individualisation trend might be counterbalanced by the increase of the formation of social groups and chosen organisations with collective interests. Several churches, religious institutions and NGOs are gaining in popularity. Some groups are even stressing their collective identity by demonstrating their unifying characteristics, which, however sets them apart from other groups and individuals. Terms like swarm intelligence, collective intelligence and the 'wisdom of crowds' and 'group think' are gaining more and more interest, thus stressing more the collective than the individual.

The increasing globalisation also goes together with the increasing regionalisation or even nationalisation. Other countertrends for individualisation are the formation of online and offline communities of people with similar interests in which people invest time and resources. Also the increasing percentage of people doing unpaid community services could point towards a countertrend to individualisation, or at least show that individualisation has not to be necessarily equalled with solitude and isolation.

2

MEGATREND

CHAPTER 4

FADING BORDERS

Opening of geographic and societal borders and the disappearance of physical and conceptual boundaries.

4.1 Geographical and conceptual borders

The process of fading borders concerns the declining and blurring of geographical and conceptual borders and limits between and within globalised societies. This causes increasing interdependencies, complexity and more interwoven influences of capital and markets. The effects on both national economies and the global economy are tremendous, creating strong interdependencies and thus making the world more complex, with more variety and uncertainty. This can be seen for example in the effect of the global financial crises, which start in one country and quickly affected the economies in other countries.

Borders are fading and have become less relevant in today's global world, at least in regard to their physical property. This is resulting in a blur that applies to different levels and patterns of change. This process of changes also applies to organisational, individual and even conceptual levels.

On a global scale there is a shift of power in which emerging economies play an important role. This results in restructurings and an increase in uncertainties within a multipolar world as well as the need for effective supra and international arrangements and agreements for governance.

4.2 Changes in the global economy

On an organisational level extended and networked enterprises are an integral part of the network-economy, whereas technology is an important driver for convergence and evolution towards merged networks and services. The globalisation of labour markets calls for a high degree in flexibility (not only in regard to travelling but also in the context of the 24-hour economy) and countries like the Philippines are training health-care workers to be sent to Europe, East Asia and the US to take care of the aging population (cf. The Lancet, 2009).

An important characteristic of today's and a future world will be the fusion of cultures and systems that previously may have been strictly separated. On the other hand, cultures and systems that fear the loss of their identity may end up diametrically opposed to each other, reinforcing differences and even bringing about serious conflicts. The distinction between the public arena and the private space is also decreasing.

Also the borders between work and home, public and private, male and female, virtual and physical reality and even the concept of life and death are blurring.

The process of globalisation – an important driver for Fading Borders - has been developing over a number of decades and even centuries. Some refer to the period of European colonialism pinpointed in 1492 when Columbus discovered America or the 'Golden Age' some centuries later, but they argue that it has now reached a new phase in regard to quantity as well as quality. The current situation can be distinguished from previous periods e.g. because it is founded on capitalism rather than international trading (Rennen, 2003).

However, in many areas the contemporary developments still seem to be in a relatively early stage and the full future influence on the economic and social development process will still to be seen. Underlying drivers for fading borders, such as globalisation, migration or changing powers will have high impacts on a global scale. Some obvious indicators are for instance the migration of people and the transportation of goods around the globe, increasing international trade and the amount of international capital investments as well as global effects a single trigger in one country can initiate (e.g. financial crisis). The most influential companies are global and they can hardly be related to a single country or even continent.

4.3 Link of the 'Fading Borders' megatrend with innovations

Fading Borders are drivers of change, influencing the more traditional, more linear ways of thinking. Technological developments such as the internet (web 2.0, 3.0 etc.) have been and will be major drivers and a foundation for the process of Fading Borders, enabling real-time capital flows, liberalisation, expansion of multinationals and foreign ownership of strategic sectors. The distinction of borders creates stronger international interdependencies and (gradual) transitions in social–technological systems often along with complexity and uncertainty.

Modern organisations are creating new ways of value creation to fulfil the needs of their customers and will develop new approaches towards collaboration, combined with the rise of self-employment. New international business models and new organisational structures and the way we organise work and our workplaces will emerge. The communication market is evolving rapidly and with it enabling new facilities.

Other manifestations of this development are for instance new forms of public and private partnerships and new ways of collaboration in 'vital coalitions' being part of the civil society or strategic alliances, new types of organisations in not-for-profits sectors such as care (assisted living centres) or education ('community schools') and renewed blurred physical forms in the things that surround us like multifunctional premises (stations, hospitals, shopping malls) street furniture or identity cards (Montfort, 2008).

Innovation, originated from fast access to and exploitation of leading knowledge, is key to competition over/access to markets. Increasing importance of R&D and transformation to added value activities and services such as design, marketing, product innovation becomes more and more crucial for the more expensive 'old world' (Europe), while at the meantime these new markets are an important selling area for the 'old' economies.

On the other hand, the 'Fading Borders' megatrend may also encourage innovations. Looking from the perspective of innovation, diversity and the avoidance of fragmentation are important conditions and indicators for success. Successful innovations are expected to be particularly transsectoral[10]. Fading Borders, fusions or blurring all implicate that many combinations are coming together. Fading Borders increasingly facilitate innovations, creating fusion and hybrid products or integrated solutions.

4.4 Impact of the 'Fading Borders' megatrend

The underlying drivers of Fading Borders, such as globalisation, migration or changing powers will have high impacts on a global scale. As the interdependency increases many will be influenced by this trend.

Fading Borders have high impact on individuals concerning their mobility, freedom of choice and their linking up with the world. Migration patterns, partly initiated by changing global demographics, will have various and significant impacts. For instance economic changes, changing consumer demands, increased demands for natural resources, changing societal values and the changing composition of workforces. This directly or indirectly influences new ways of life, new relationships, new values and new attitudes.

- At micro level: important condition for the quality of life/wellness in general
- At meso level: other size of scale of vulnerabilities and risks, also other size of chances
- At macro level: influencing economical/political stability processes

10 prof. dr. ir. Nico Baken is coined for the concept of transsectoral innovation, Delft University

FIGURE 16: Impact analysis of megatrend Fading Borders on different Socio-Technical Networks

In general - as can be seen in figure 16 - the impact of the megatrend Fading Borders is the largest on the Capital markets, concerning the global, rapid and free flow of capital to conduct facilitate financial transactions. There is also quite a high impact on several other STN domains, such as Communication and information, Quality of Life and Defence, safety & security.

4.5 Background analysis of the 'Fading Borders' megatrend

4.5.1 Globalisation causes increasing interdependencies, complexity and more influence of capital

For centuries, nation-states with clearly defined borders have been the dominant political and economical entities. Almost all of these borders created a division of people along these lines. In history, these borders have often been altered as a result of major conflicts, but the sovereignty of the nation-state was central. But since the end of the 20th century – with the fall of the Berlin Wall in 1989, and the subsequent collapse of the Soviet Union – the globalisation of the world economy has made state borders less important. Strategic alliances have developed to allow more economic and cultural interaction.

The globalisation process still continues, while being a complex phenomenon. It is "the interactive co-evolution of millions of technological, cultural, economic, social and environmental trends at all conceivable spatiotemporal scales" (Rennen, 2003).

In Europe, the accession to the EU of ten new Member States in 2004 and Bulgaria and Romania in 2007 confronted the 'old' Member States with the consequences of the fading internal EU borders. Questions arose such as whether they should open their labour markets to citizens from the new Member States and how each country could benefit. These issues will change over time.

Economic systems such as international trade and capital markets play a central role. In his analysis about globalisation, Friedman[11] refers to the 'golden straightjacket' as a term for describing the situation where individual counties sacrifice some degree of their economic sovereignty to global institutions (such as capital markets and multinational corporations).

4.5.2 Migration is shaping the face of the globe in the coming decennia

Migration is expected to be a significant factor for shaping the face of the globe in the coming years. Global migration affects every country in the world. Various factors are likely to increase global migration until 2020, making even relatively homogenous states more diverse. Political and environmental factors can also influence migration streams, e.g. due to flooding and droughts or war and unrest. But it is not only about physical migration streams but also about foreign investments, trade liberalisation and enhanced communications. Within countries environmental structures will change as well. By 2015, for the first time in human history, a majority of the world's population is expected to live in cities and by 2030 this number will reach 60% of the population.

11 Thomas L. Friedman, American author and columnist of The New York Times. Friedman is an advocate of globalisation, in his book "The Lexus and the Olive Tree" (1999) he also points out the need for local adaptions

FIGURE 17: Net migration (per year in thousands)

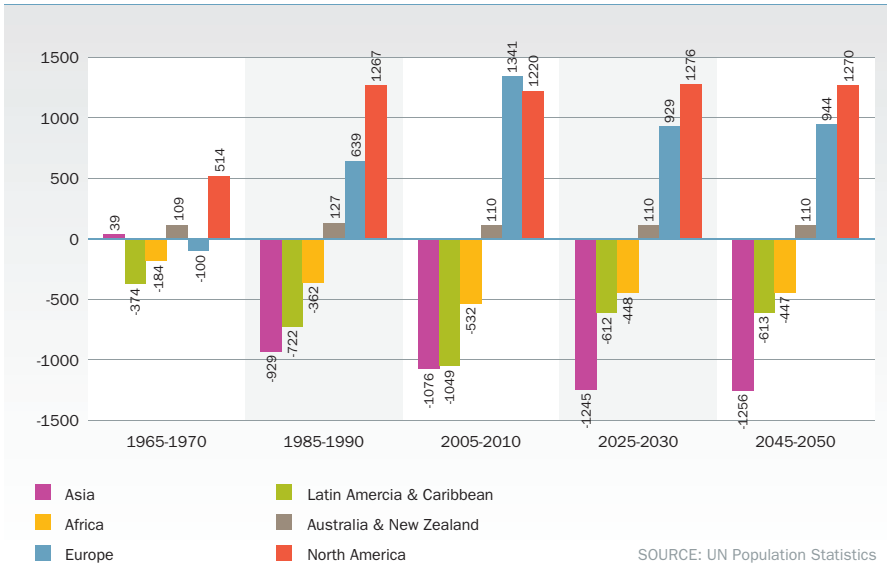
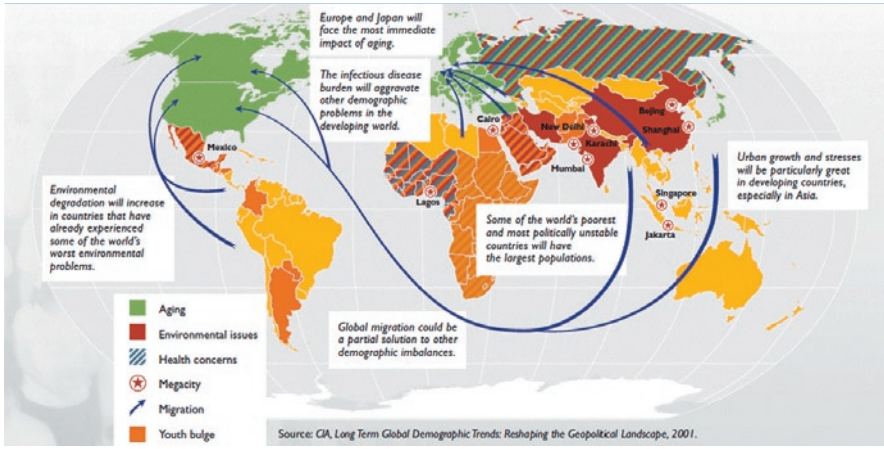


FIGURE 18: Long Term Global Demographic Trends: Reshaping the Geopolitical Landscape



The economic, scientific and population growth rates of countries such as China and India will have a high impact in the coming decades. As most of the population growth is taking place in today's developing and emerging countries, it seems likely that Asian culture will profoundly shape global interactions, societal values and behaviours. This can already be seen in regard to biotechnology, for example, where the conditions and laws in Asian countries like Singapore, China and South Korea

(e.g. in regard to (embryonic) stem cell research) seem to be more favourable than in many European countries.

4.5.3 Changing powers create a multi-polar world

In a world with new uncertainties and global risks the concept of 'superpowers' attributed to a limited number of countries is not as straightforward as it used to be. Predicting which regions or nations will emerge as a future global economic and political power is difficult. This is a matter of ongoing debate. Another theory is that today's complex global marketplace and the rising interdependency between the world's nations lead to a multi-polar world and makes the concept of a superpower an idea of the past.

Projections suggest that in the future the USA may no longer be the world's biggest economy. Today's developing economies such as the BRIC countries - Brazil, Russia, India and China, but also others such as Mexico, South Korea, South Africa, or Turkey - have the potential of achieving superpower status in the 21st century. The European Union may play an important role in this process and a 'new kid on the block' could be Dubai.

High uncertainties that influence the trend of changing powers and underlying trends for this shift in economical relations are for instance a high demand for energy and rise of oil prices, major climate and environmental effects, monetary ratio's (in particular the exchange rate of the US dollar and the Euro, strongly influenced by the worldwide financial crisis and the financial influence of governments), political quota and –barriers that influence markets and trade relations, outsourcing and offshoring of labour, the draining away of traditional industries, competition for human talent, Asian innovators and a brain drain from the 'old' world. Further utilisation of renewable energy sources could also lead to changes in economic power as the dependency on oil may decrease.

4.5.4 Decreasing distinction between the public arena and private space

The public versus private distinction in Greek philosophy was based on a public world of politics and a private world of family and economic relations. In present western societies it refers to the influence of the governments and is closely connected with processes of privatisation, free market systems policies and public-private partnerships.
The distinction between the public and private sphere is currently undergoing steady erosion as a result of a variety of political and legal developments, as well as economic, technological and social forces. The withdrawal of governments from welfare states combined with a growing influence of markets and private partnerships is one example. It creates new situations and raises questions over governance, public

responsibilities, ethics (integrity, transparency, trustworthiness) and other issues. Privatisation resulted in an interwoven ownership of central public areas such as utilities, health and transport.

For governments it became more difficult to operate within these new settings, resulting in a struggle of finding a balance about where and how to act or withdraw and to find a way between regulation and non-regulation. At the same time governments have to take the responsibility for ensuring public values and guaranteeing a system of checks and balances, thus redefining some of their core tasks.

4.5.5 Extended and networked enterprises are part of the network-economy

A changing environment with globalisation of markets, new enabling technologies and the network economy has influenced organisations. The 'extended enterprise' concept represents the boundless organisation, made up not only of its employees but also its business partners, its suppliers, and its customers that operate around the world. This includes many related arrangements such as virtualisation, sourcing, distribution agreements, supply management, remote collaboration, open innovation with joint program partnerships and customer partnership. The extended enterprise is part of one or more value webs where innovative business models are an important basis for commercial successes. This extended enterprise has to be agile and continuously being able to adapt to changes. Fading Borders also affect and complicate intellectual property (rights).

4.5.6 Global labour markets create high needs for flexible workers

While flexibility (or 'flexicurity', an EU concept combining flexibility and security needs) will become increasingly important, employability and entrepreneurial competences of employees are much emphasized. For various economical and individual motives there is a tendency towards a rise of self-employment (EU, 2005). Mobile employees are increasingly in demand. More and more people are working remotely, in 'virtual' teams, where employees manage their international responsibilities via regular communications link-ups and frequent business trips.

In a service economy which strongly depends on creativity and innovation, the challenge for organisations is to employ engaged workers where competences like creativity and soft skills are considered a key differentiator. The future workplace, culture, management and tools will also change and are largely driven by the IT-developments and innovations. However, today many organisations still tend to operate in a culture of 'presenteeism' where productivity often is measured by hours spent at work rather than in results. Also teleconferencing is still not as widespread as technological possibilities might already allow for.

According to the analysis of Friedman, globalisation will create homogenous global markets for products and services, but also for labour. He reasons that labour which can be distributed by networks will be conducted where wages are low.

He distinguishes different levels of vulnerability looking from an employees point of view: a limited group of workers who are extraordinary (e.g. people like Michael Jordan or Bill Gates), workers who are specialized and more difficult to replace (e.g. key accountants, brain surgeons, cutting-edge computer architects), workers who are really adaptable and as a final category the 'touchables', whose labour can be relatively easily replaced elsewhere (Friedman, 2005).

4.5.7 Technological convergence, evolution towards merged networks and services

New players emerge and competition increases. As a result new partnerships are being formed and old boundaries for conducting business between telecom, computer and media industries fade away. New technologies (such as IP Multimedia Subsystem[12] (IMS) or development of radio technology combined with open standards) enable converged and often portable and personal services, regardless of platforms, devices et cetera (Ericsson, 2005).

The IT-revolution has been a central driver for fading borders. Technology plays a strategic role, both as being part of the fading border process and also as a driver for opportunities for change. Seamless technology facilitates worldwide collaborative relationships and international as well as inter-organisational operations. It enables the openness, immediacy, information sharing possibilities, flexibility and adaptability that the extended enterprise demands. Information technology also enables customer responsiveness, speedy decision making and operational planning.

12 IP Multimedia Subsystem (IMS) is a set of specifications that describes the Next Generation Networking (NGN) architecture for implementing IP based telephony and multimedia services. (www.ibm.com)

4.5.8 Loosening the borders between work and home and inner and outer worlds

In many aspects the distinction between private and working life are less divided than some decades ago. Forces behind this development originate in political and social aspects like the increasing labour market participation of women, economical self-supportiveness and a more equal distribution of paid and unpaid work. Changing family forms or the demographic pressure from an ageing population are already major topics on the European social agenda (EU, 2005). From an economic and employer's perspective there is more need for more flexible working hours, encouraging the supply of public and private services.

A significant driver is the use of ICT, which enables more and more people to work anytime and everywhere. It enables changes in the office, to work from home and have flexible working hours. Also people e-mail, surf and chat during working hours for private purposes while working at home outside the office hours. Even at an individual, personal level the limits between the outside and the inside are blurring. More and more people share their intimate believes, attitudes and 'secrets' with the whole world via blogs, reality TV and chat shows. While on the one hand private activities are willingly made public, the concern over privacy protection and fears about surveillance are growing on the other.

Traditionally, many innovations were first adopted in the business sector and later diffused into the consumer market. Today it is often the other way around: consumers are often the first ones to apply new technologies which are later taken up in business environments. In regard to ICT and multimedia applications, some of today's households are better equipped than offices. It is often the employees who introduce new needs and technologies to their work setting.

4.5.9 Fading conceptual borders

Individualisation as well as modern technology has also led to the fading of conceptual borders such as between male and female or natural and artificial. Traditional role divisions between men and women as well as occupational differences are more and more fading away especially in post-modern 'western' countries. But also the distinction between 'natural' and 'artificial' are fading with humanoid robots, interactive technologies, Artificial Intelligence, synthetic biology and artificial life and real-life 'cyborgs' (cf. Megatrend The Intelligent Age).

4.6 Counter-developments can influence the tempo of the fading of borders

Some important counter-developments that may strongly influence the (tempo of the) process of the blur between and within societies on different levels:

1. **Social-cultural**: localisation or regionalisation can be named as important counter-trends for globalisation. As multiculturalism enters society through migration and trend-adaptations from around the world, nationalism, integration, tradition and even xenophobia as well as the search and importance for ones own cultural identity are also becoming relevant topics.

2. **Political/ideological**: (potentially) increasing risks of a clash of cultures, religions and ideologies and/or political instability as well as anti-globalisation movements can also be observed and represent a counter element against fading borders (cf. Huntington, 1996). Around 2010 nationalist and conservative movements and political parties have also gained ground in Europe.

3. **Political/economical:** protectionism, security concerns and the conservation of trade interests represent barriers that are limiting the mobility of people/goods, competition and/or access to energy resources, the intention to cooperate and to reduce the gap between rich and poor countries. But also within countries, the economic situation may become even a larger dividing factor than culture.

3 MEGATREND

CHAPTER 5

MANAGING ENVIRONMENTAL SUSTAINABILITY

The rising consciousness over environmental issues drives innovation.

5.1 'Environmental Sustainability' is aimed at resources to last longer

Sustainability can be defined as developing ways and technologies to make resources last longer. This megatrend also refers to the awareness in particular in western societies about the boundaries of the wasteful 'modern' way of life. Sustainability includes the search for more efficient production methods, the utilisation of alternative materials (i.e. organic materials that can be regrown), renewable energy sources, recycling, conservation, the long-term availability of clean water, clean air and safe food as well as concepts for improving living conditions and quality of life.

In 1987 the World Commission on Environment and Development (the Brundtland Commission) provided the following definition: *"Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (UN1987)

In this sense it is regarded as a three dimensional concept that includes environmental protection, economic growth and social development. In recent times the aspect of environmental protection has become the focus of attention and is currently influencing economic and societal development to a greater extent.

5.2 The status quo will lead to problems

If eco-sustainability measures will not be implemented, in 2030 the world's annual total energy use is likely to amount to 17095 Mega tonnes of oil equivalent (Mtoe), an increase of 5900 Mtoe relative to 2004, and CO_2 emissions will rise to 40420 tons, a 55% increase relative to 2004 (IEA 2006). More than half of the tropical rainforests might be lost. By 2025 1.8 billion. people could live in water-scarce and 3 bn. in water-stressed areas and water pollution might rise (Glenn/Gordon 2007). With a global population growth of 1.27% until 2030 to 8.3 billion people (UN population statistics), an increasing amount of resources would be necessary to sustain the growing number of persons, not to mention trying to improve the living standard of the currently poor, especially if humanity will continue with the wasteful status quo.

The importance to solve global environmental problems and to ensure the availability of basic resources like clean energy and clean water will continue to stay a top priority on an international level. Managing Environmental Sustainability is a trend that will remain important as well as necessary for a long foreseeable time, even if some of the current grave problems may get resolved. The trend is unlikely to reverse in a fundamental way as improved technologies and possibilities already exist and sustainability has become an important driver for innovations and the development of new products and production methods.

5.3 Link of the 'Environmental Sustainability' megatrend with innovations

The rising awareness over environmental problems (incl. energy) can also be seen as a chance to invest into resources and knowledge to make better use of renewable energy sources, energy-efficiency, to manufacture less harmful products, improve production methods and even think about alternative concepts of energy distribution like decentralisation. Environmentalism can be seen as a driver for innovation with many spill-over effects.

Improving sustainability has become a new and important factor for competition and innovation in all industrial sectors. Environmental technology is seen as a huge innovation field and will generate new jobs, especially in the European Union ('Green Jobs'). The EU is already a very strong player in the area of eco-industries, having a share of about 30% of overall global turnover. In Asia, Japan is very advanced in regard to energy and environmental technologies and her development may have a positive effect on other Asian countries like China. By 2020 the worldwide environmental technology market is estimated to achieve 2300 bio. Euros, a doubling of current values. In the EU, environmental technologies currently account for 2.2% of the GDP and have created 3.4 million jobs. Europe is especially innovative in the areas of eco-friendly construction, transport, waste management and the food and drink sector (cf. European Commission 2008).

5.3.1 Environmental issues create new markets and opportunities

The growing interest and necessity for sustainability has also generated new markets, products and consumer groups (e.g. LOHAS – short for 'Lifestyle of Health and Sustainability') as well as research interests like bionics, new energy technologies and water management. The search for sustainable solutions is also likely to foster interdisciplinary cooperation, an approach that looks promising in many areas of science and technology. The appearance of 'brighter', i.e. more innovation- and technology-friendly versions of the environmental movement also points to the direction of a more innovation- and technology-driven approach towards sustainability, thus contrasting the 'classic-green' advocacy for relinquishment.

BOX VII: A sample of innovations linked to the 'Environmental Sustainability' megatrend

– Energy efficiency technology
– Renewable energy
– Alternative biofuels
– Hybrid / electric cars
– Next-generation solar cells and wind turbines
– Artificial life for energy production and pollution cleanup
– Combined-heat and power (CHP)
– Carbon filtering and capture technologies
– Alternative energy distribution concepts
– Green ICT
– Earth surveillance and simulation
– Low-/ zero energy house
– Desalination technology

5.4 Impact of the 'Environmental Sustainability' megatrend

If the status quo continues and current environmental efforts will come to a halt, the negative effects on living conditions and quality of life could become be very grave. Also taking into account the expected growth of the world population and the economic growth of emerging economies will bring about huge sustainability pressures. Not only fossil fuels, but also resources like food and clean water could become scarce and extreme weather conditions, flooding and draughts could become more frequent. Environmental refugees, wars over resources as well as spreading (re-)emerging diseases might be the consequences.

Although environmental problems are a global issue, it is poorer nations that will suffer most. Africa, South America and parts of Southern Asia would be most affected from climate change, diseases, food and water shortages, draughts and will have the most difficulties in protecting themselves against harm (e.g. flooding, storms etc.). But also more developed countries will be effected, especially Southern Europe, which already faces growing desertification today. The effect will be felt on all levels, from nation-states to individuals who will be confronted with high energy bills and possibly increasing food prices.

Therefore the development of cleaner energy technologies, improved energy efficiency, waste reduction, recycling technologies and improved filter systems will remain very important for the economy as well as for humanity as a whole. Many countries are on a good way to create eco-economies, where ecological considerations are transformed into economical benefits.

FIGURE 19: Impact analysis of megatrend Environmental Sustainability on different Socio-Technical Networks

The impact of the megatrend managing Environmental Sustainability has a huge impact on the Socio-Technical Networks of utilities and transport, because they are mostly affected by environmental policy, criticism and efforts for change. The living environment is also influenced, especially in regard to the way how humans perceive and deal with their living environment. Building designs and city planning may change as well as the management and preservation of natural habitats. Also the quality of life will be affected either positively through improvements due to successful efforts and the acceptance of sustainable life-styles or negatively if efforts fail or people may feel too restricted due to eco-regulations.

5.5 Background analysis of the 'Environmental Sustainability' megatrend

5.5.1 Finite nature

Back in April 1968, an international group consisting of professionals from industry, diplomacy, academia and civil society have began to outline their view of future development which have been published in their report "The Limits to Growth" in 1972 (Meadows et al. 1972) that gained worldwide reputation and caused much discussions. The basic message has been that there will be a profound conflict between the needs of a growing world population and the limitation of resources. This has even led to countering proposals for developing (science-based) ideas for a post-scarcity society (cf. Drexler 1986, 2007).

Whereas post-scarcity is quite likely to remain unrealistic, as long as physical resources are necessary, improvements in energy efficiency and renewable energy sources could take off some burden from extreme scarcity scenarios. But therefore global-scale changes have to take place. The latest updated version of "Limits to Growth" suggests that the 1972 predictions are basically correct if the status quo continues and that humanity may quite probably face grave shortages and environmental as well as socio-economic problems within the next 70 years (Meadows et al. 2004).

5.5.2 The hunger for energy

Statistics that extrapolate the current tendencies in regard to energy consumption and carbon-emissions provide a quantitative reference points for future developments if no significant activities in regard to energy efficiency and renewable sources are taken. In a status-quo extrapolation scenario the world's annual total energy use is likely to amount to 17095 Megatonnes of oil equivalent (Mtoe) in 2030, which is an increase of 5900 Mtoe relative to 2004. China's and India's energy consumption could together represent 26% of the global total. At the same time CO_2 emissions will rise to 40420 tons, a 55% increase relative to 2004 (IEA 2006).

FIGURE 20: Two scenario's for share of energy sources in the European Union 1990 – 2030 as business as usual scenario (left) and environmental policy scenario (right)

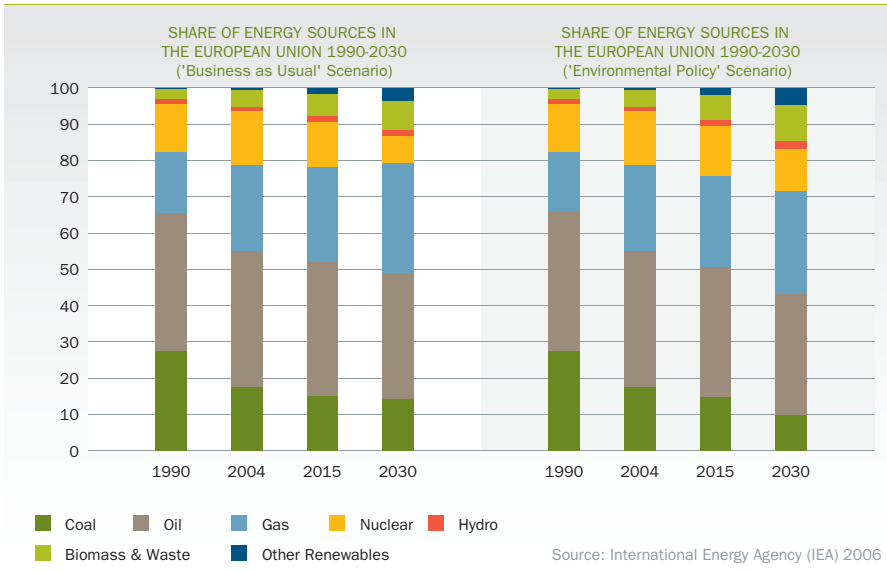
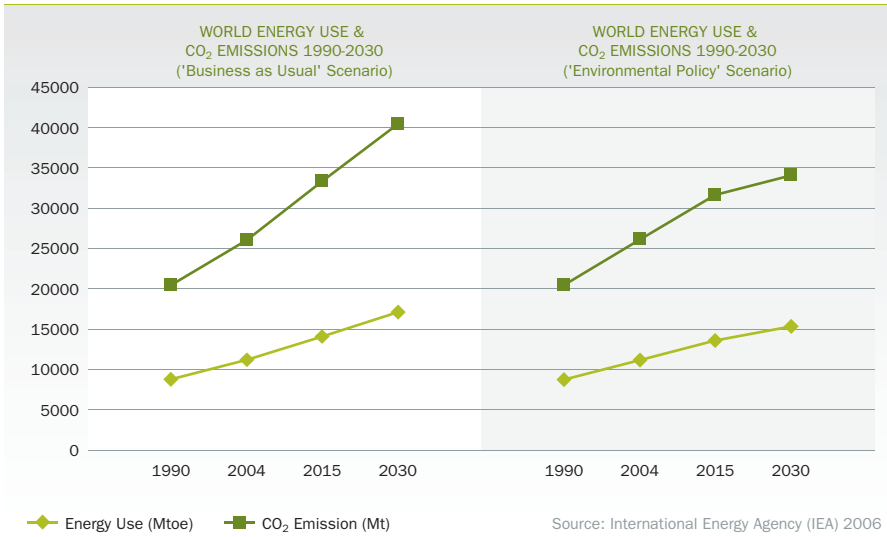


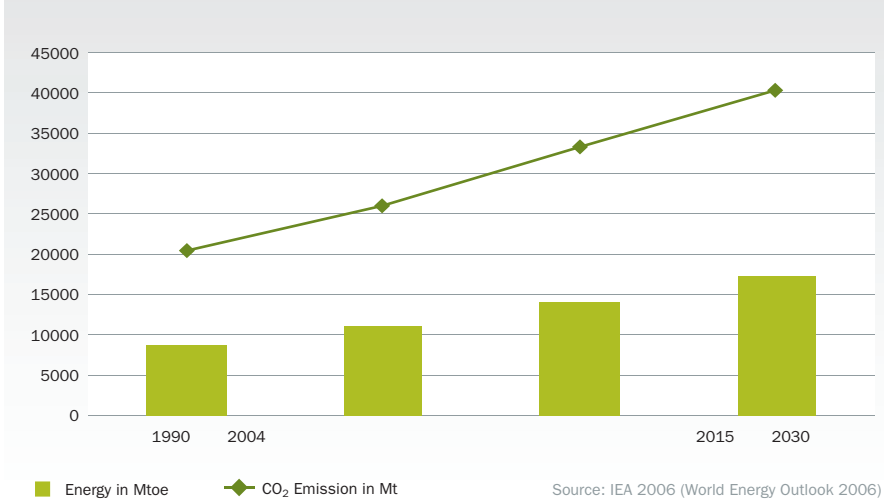
FIGURE 21: Two scenario's for energy use and CO_2 emissions 1990 – 2030 with business as usual (left) and environmental policy implementations (right)



More than half of the tropical rainforests might be lost. By 2025 1.8 billion people could live in water-scarce and 3 billion in water-stressed areas and water pollution might rise (Glenn/Gordon 2007). The current human demand for resources is higher than the ecosystem's ability to regenerate. The 'Global Footprint Network' has estimated that currently 1.3 'earths' would be needed to meet the required resources to sustain humanity at an acceptable level. The '1 earth' threshold has been reached in 1986[13]. With an expected global population growth from 6.5 billion in 2005 to 8.3 billion people 2030 (UN 2008), an increasing amount of resources would be necessary to sustain the growing number of people, not to mention trying to improve the living standard of the currently poor, especially if humanity will continue with the wasteful status quo.

13 http://www.footprintnetwork.org/

FIGURE 22: Global Energy demand in million ton of oil equivalent (Mtoe) and CO_2 emission in Mega tonnes (Mt) *(business as usual scenario)*



5.5.3 *Development: from grassroots to global issues*

In April 1968, a small international group of professionals from the fields of diplomacy, industry, academia and civil society met at a quiet villa in Rome: the start of the Club of Rome. In 1972 their activities gained a new worldwide reputation with the first report "The Limits to Growth", which had a high international impact in the fields of politics, economics and science and bringing the issue on the global agenda (Meadows et al. 1972). The latest updated version of "Limits to Growth" suggests that the 1972 predictions are basically correct if the status quo continues and that humanity may quite probably face grave shortages and environmental as well as socio-economic problems within the next 70 years (Meadows et al. 2004).

Since the rise of public awareness about environmental issues and the formation of environmental movements and 'Green Parties' in the 1970s environmental issues have become increasingly important for politics as well as the economy and are nowadays often used synonymously with sustainability. By now environmental topics are an established part of the political agenda in most states and most post-industrialized countries have green parties and environmental award systems. 'Managing Environmental Sustainability' has become a global challenge for humanity (Glenn/Gordon 2007) and has already transformed the mode of thinking in politics, consumer mindsets and behaviour as well as the industry. However, there are still large gaps between intent and real action.

5.5.4 Political and social environmentalism

The word sustainability is nowadays widely used in the context of environmental concerns and has already influenced many aspects of society from governmental laws and regulation over industrial production to consumer's choices and lifestyle preferences.

The current human demand for resources is higher than the ecosystem's ability to regenerate. A growing number of governmental and non-governmental agencies has now adopted the term of 'ecological footprint' as estimation for how many earths are needed to meet the resource requirements of humanity given a specific time in history or way of living. According to the Global Footprint Network, the ecological footprint of humans has reached a value of 1 (=1 earth) in 1986 and has been at around 1.25 in 2003 and is currently at 1.3[14].

By now there are many different environmental organizations and 'Green Parties' that try to tackle environmental problems in different ways. Whereas the so-called traditional 'dark green' movement (sometimes also referred to as 'Deep Ecology') makes the modern form of industrialisation, capitalism and technology responsible for environmental endangerment, the 'light greens' regard environmental issues as important, but see it rather as a matter of individual choice than a political issue (a libertarian stance). A new group, the so-called 'bright greens' have quite recently emerged as the 'techno progressive' wing of the ecology movement. They see the solution for current environmental problems in the development of better, new and emerging technologies and innovations, including modern nano- and biotechnology.

Environmental protection is now a proclaimed goal of many governments and international organisations, being implemented through a variety of activism, protests, laws and regulations. Nonetheless, international conferences and agreements on environmental and climate protection issues still rather represent goodwill than providing binding obligations.

5.5.5 Environmentalism as way of life

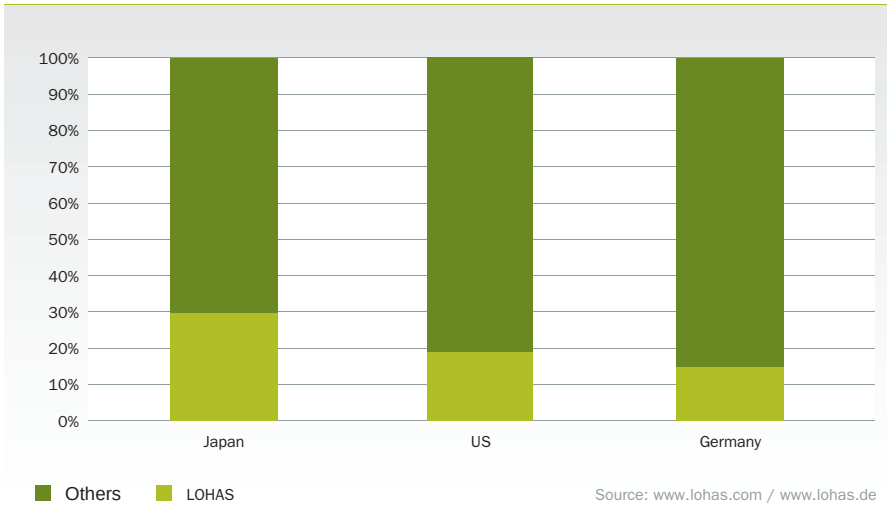
Environmental protection also enjoys widespread backing in the European population and to an increasing amount in the USA and Asia. The notion of 'climate change' has been accepted by most scientists and politicians. An increasing number of consumers begin to integrate sustainability factors into their consumption choices and many celebrities present themselves as LOHAS ('Lifestyles of Health and Sustainability') and serve as role models. Since the 1970s, within 30 years, environmentalism has

14 http://www.footprintnetwork.org/

established itself as a new way of life by integrating different cultural facets. Post materialist ideals fused with healthy living (incl. the eco-food movement and wellness trend) and nature-based religious orientations (e.g. Asian religions, Shamanism, the successors of new age and heathenism). The emerged consumer group LOHAS are generally financially well-off, well educated and interested in high-quality, sustainable and health-improving products. Therefore, especially the segment of LOHAS consumers can be regarded as a growing class of customers for environmental sustainable innovative products with an emphasis on ecological production, sustainability, natural materials and fair trade. 15% of Germans, 19% of US consumers and 30% of Japanese consumers can already be roughly classified as LOHAS. Therefore this Lifestyle may qualify as a newly emerging Mega Trend[15].

In contrast to the LOHAS (and Bright Greens) stand the LOVOS (short for 'Lifestyles of Voluntary Simplicity') who are on the 'Dark Green' side of the spectrum and are generally sceptical about consumption, materialism, industrialisation and technology.

FIGURE 23: Share of consumers who consider themselves as LOHAS (2006)



15 http://www.lohas.com/about.html; http://www.lohas.de/; http://www.japanfs.org/en/newsletter/200606-1.html

5.5.6 *Different shades of 'green'*

By now there are many different environmental organizations and 'Green Parties' that try to tackle environmental problems in different ways. Whereas the so-called traditional 'dark green' movement (sometimes also referred to as 'Deep Ecology') makes the modern form of industrialisation, capitalism and technology responsible for environmental endangerment, the 'light greens' regard environmental issues as important, but see it rather as a matter of individual choice than a political issue (a libertarian stance). A new group, the so-called 'bright greens' have quite recently emerged as the 'techno progressive' wing of the ecology movement. They see the solution for current environmental problems in the development of better, new and emerging technologies and innovations, including nano- and biotechnology. Environmental protection is now a proclaimed goal of many governments and international organisations, being implemented through a variety of activism, protests, laws and regulations. Nonetheless, international conferences and agreements on environmental and climate protection issues still rather represent goodwill than providing binding obligations.

5.5.7 *Increasing relevance of environmental concerns*

On one hand, statistics and calculations about energy consumption, pollution and greenhouse-gas emissions are quite straightforward and very well demonstrate where we could be heading (IEA 2006). CO_2 and greenhouse emissions and energy consumption as well as water pollution, deforestation and desertification rates are recorded in diverse statistics (e.g. IEA, UN databases, EUROSTAT), which all show an increase. About 20 to 40 ha (depending on the sources) of tropical rainforest are cut down every minute, possibly irreversibly destroying animals, plants and their habitat.

Also on the social side, there exist quantitative and qualitative indicators which show that environmental concerns are getting increasingly relevant. The growing interest in fair trade, organic food, local markets, natural materials, hiking and eco-tourism, animal rights, nature-related spirituality and LOHAS as well as LOVOS lifestyles can be named as indicators. This provides the industry with an incentive for more eco-friendliness.

Also sustainability is getting increasingly integrated into the economic logic (e.g. 'green taxes', emission trading, corporate responsibility as competition advantage) and the Dow Jones Sustainability Index records the financial performance of global sustainability driven companies and countries are ranked according to their environmental performance (e.g. by Yale University). It is likely that sustainability will be considered 'normal' in another couple of decades, probably at an unconscious level.

5.5.8 *Conflicts over basic Needs*

Environmental problems are also becoming a security issue. If the status quo in regard to population growth, declining arable land, draughts, desertification, wasted energy and resources and water pollution continues, global conflicts and even wars over basic needs like water, food and energy will become likely. If the worst-case scenarios of global warming will come true, large parts of the world, especially in developing countries will be flooded or dried out. Post-industrialised countries could be facing huge numbers of environmental refugees, a situation that may have profound destabilizing effects (Myers, 2005). Therefore it would be in the interest of all to co-operate and find solutions to improve the current global environmental situation.

But it is also economic activities like speculation at stock markets that contribute to the rising food and energy prices.

5.5.9 *The technological capabilities do exist*

Humanity has now reached a stage of innovative and technological capacity that allows them to develop more sustainable products and methods of production, renewable and cleaner energy, to produce more food, reverse harm already done to the environment and protect against possible dangers while providing good living standards for all. Innovative initiatives such as the 'cradle to cradle' concept could extend the sustainability intentions into a new design paradigm where "The Next Industrial Revolution is the emerging transformation of human industry from a system that takes, makes, and wastes to one that celebrates natural, economic, and cultural abundance." (cf. Braungart, 2002[16])

With Masdar City, Dubai/UAE is currently constructing what will be the future hub for environmental technology. Here latest renewable energy technology as well as concept for environmentally friendly transport and city-planning concepts will be installed and tested. Above this, Masdar City is ought to bring together global research and development in environmental technology. The Japanese 'Kameyama Plant No. 2' of electronics giant Sharp, claims to be the world's most environmentally-conscious manufacturing facility.

Principally the current problems and practices are not primarily technological in nature but rest in lags and inaction due to economic, political and societal reasons.

16 Also refer to: http://www.mbdc.com/c2c_nir.htm

5.5.10 Eco innovation

The growing necessity for more eco-sustainability is also providing great chances for the economy. Since in every area from energy generation over industrial production to transportation and households (and even toilets in regard to water efficiency), improvements towards more sustainable solutions are possible, a new dimension is added to innovation. Car manufacturers can improve on fuel efficiency and the reduction of carbon-emissions, the demand for new solar panels and wind turbines is growing, producers of computer and server technology think of ways to reduce the energy consumption for system cooling, leading to a new innovation segment called 'Green ICT' and the construction industry gets new assignments for improving the insulation and energy efficiency of old and new houses. Energy and environmental technologies also represent an area where experimentation with different approaches ranging from low-tech and the rediscovery of traditional methods to high-tech solution from the domains of nanotechnology and experimentation with 'artificial life' (e.g. modified organisms that can clean up contaminations or produce energy). Environmental technology will also be an important factor the European economy and job market . By the year 2020, Germany could have more jobs in the area of environmental technology than in the automobile industry and a 20% increase in energy-efficiency could create about 1 million jobs in Europe (UNEP 2007).

Nonetheless, a real environmental consciousness is still emerging and not as widespread in society as one might expect. Even in Germany, a country that often prides herself as a forerunner in environmental protection, according to a 2007 'Institut für Demoskopie Allensbach survey' only 23% of the respondents (N = 21058) were very much interested in the protection of nature and the environment, whereas 53% were somewhat interested and 24% not interested at all (Allensbach, 2007). Counter-developments that are partially associated with so-called climate-scepticism can also be observed and some people and groups are also calling for changes that take the economic and more human-centric perspectives of sustainability more into account.

5.6 Several countertendencies show a gap between promises and action

5.6.1 Economic factors

There are always two sets of scenarios for this issue: one representing a more favourable practice and the other the continuation of the status quo. If the status quo is more convenient or economically advantageous efforts in improving ecological sustainability may decline. One example is the number of private road vehicles that is currently rising and may even amount to 2 billion vehicles in 2030 (Dargay et al. 2007), despite conventional road vehicles are being made responsible for environmental

destruction. The replacement of old technologies by new ones and investments in more eco-sustainable means and practices is still costly and companies are rather hesitant to be the first.

5.6.2 The tendency of 'greenwashing'

Also the growing tendency of production offshoring may counter local ecology-investments in post-industrialised countries by shifting dirty production to emerging and developing countries plus adding up transport. There also exists the tendency of 'greenwashing', i.e. advertising a product as ecologically friendly, whereas it is actually not. Above this, global environmental policy still proofs difficult due to different interests of single countries and so far only ended up in rather symbolic acts than real binding obligations with sanctions. As the economic growth of many post-industrialised countries is beginning to slow down, other topics like growth in production, efficiency and cost reduction may scale down environmental concerns. If looking at the figures of the environmental expenditures and investments by the industry as percentage of the GDP from 1995to 2004, it actually looks as if efforts are declining or at least do not show a stable increase. Especially in environmental issues there can be a great gap between promises and action.

Governments are also currently stressing that environmental considerations should not be sacrificed due to the present global economic crisis.

5.6.3 Global warming dispute

Although (nearly) all scientific institutions agree on the fact of global warming and the fact of human contribution (anthropogenic), in 2010 there is still a public and political dispute going on over anthropogenic global warming. There exist many dimensions to the dispute, including about the relation between carbon-emission and warming and the question about in how far human activities are playing a role for the developments. Some even deny the notion of 'global warming' and 'climate change' in general. Especially here it has become increasingly difficult – even for experts - to assess the reliability of different information and stances and especially the underlying political or economic interests. As long as such disputes over fundamental questions exist, unified action remains difficult.

4

MEGATREND

CHAPTER 6

RISKS AND SECURITY CONCERNS

New risks and the relevance of precaution and foresight in a complex world.

6.1 Risk and precaution

Over the past decades, especially in Europe, the notion of risks has become closely linked to the negative consequences of human technological and economic activities on health, security and the environment. Above this, the things feared to be at stake have even shifted beyond immediate threats to human life and physical health to concerns over potential harms for wellbeing, the maintenance of good living standards, long-term effects of the unknown and even ethical considerations. Risks are not regarded as a fate anymore, but as something that could and should actually be prevented, which let to a growing professionalisation of risk assessment, prevention and disaster response.

As Ulrich Beck (1986) and Anthony Giddens (1990) noted, the preoccupation with risks, especially those caused by human activity, can by now be regarded as an integral part of (post-) modern societies. Great efforts were taken to transform decision making from a reactive mode towards precaution, i.e. trying to prevent potentially negative outcomes in the first place. The so-called precautionary principle is well established in the policy making of the United Nations (1992), the WTO (1995), the European Commission (2000) and in other post-industrialised countries. It legitimates governments to intervene if the (reasoned) assumption of possible harm exists, even before full scientific evidence of risks is actually established. The precautionary principle originated in Germany in the context of the environmental debates of the 1970s and has an even longer tradition rooting in the German 'Vorsorgeprinzip' which is translated into English as 'precautionary principle'.

BOX VIII: Definition of the 'vorsorgeprinzip' or 'precautionary principle'

As of 2000 the European Commission uses this definition: "The precautionary principle applies where scientific evidence is insufficient, inconclusive or uncertain and preliminary scientific evaluation indicates that there are reasonable grounds for concern that the potentially dangerous effects on the environment, human, animal or plant health may be inconsistent with the high level of protection chosen by the EU".

6.2 Globalisation of risks

The continuation of globalisation, growing international exchange and dependency leads to new tensions, uncertainties and challenges necessitating a better control of borders, information distribution (e.g. in regard to terrorist information and propaganda), financial systems and illegal trafficking. Since globalisation, free trade and open borders also have positive effects the guarantee of security is always a balancing act between control and freedom. Around 2 trillion USD are daily transferred inter-

nationally via the Internet (Glenn/Gordon 2007), which may harbour criminal activities and lead to attempts of identity theft.

From the side of policy-makers terrorism remains a major risk with almost every country and the UN General Assembly having implemented anti-terrorism legislations and strategies. The budget of the US FBI has risen from 3.2 billion. USD in 2001 to 5.7 billion. USD in 2005, mostly for funding anti-terrorist activities (Whitehouse 2007, Glenn/Gordon 2007). Other risk and security topics deal with a strengthening of Chinese and Russian power, instability in the Middle East, new countries obtaining nuclear technology with weapons grade potential and concerns over the safety and legality of internationally distributed products. The global military expenditure has risen from 960 billion. USD in 1992 to 1214 billion. USD in 2007 (SIPRI 2008). As weapons may become smaller, smarter and more sophisticated, the assurance of security will become increasingly challenging. The global market for nuclear, biological and chemical (NBC) and explosive detection devices is expected to grow from 1.7 billion. USD in 2006 to 3.5 USD in 2012 (BCC 2007). But it is also likely that technologies invented for security and protection (e.g. surveillance technology, encryption systems or biological agents created to detect harms and reverse damage) could also be used for destructive purposes (e.g. for espionage, transfer of secret information between terrorists, or as biological weapons).

Terrorism may continue to remain a general topic especially for governments, although s shift to new forms attacks directed at a country's information infrastructure is likely. Attacks on a country's information infrastructure may not even require costly materials and can be even performed from a safe distance at rather low risk for the potential attacker. Also the face of warfare may shift from regular military battles between armies to an increased number of attacks organised by small groups like terrorist cells which are harder to predict and to prevent.

6.3 Link of the 'Risks and Security' megatrend with innovations

6.3.1 Risky innovations

Since innovations are by definition novelties with practical application that lack empirical value, risk concerns over impacts of new technologies and processes can hinder the successful realization of innovative ideas. Especially those technologies which are generally regarded as emerging key technologies, i.e. advanced nanotechnology, genetic technology, neurotechnology and to a certain degree artificial intelligence, are also perceived as risky and already discussed with controversies on high levels in governmental and non-governmental organisations. Especially in respect to perceived radical innovations, there seems to be an inherent conflict between innovation and

risk prevention. The concern over technological risks and especially their ethical implications seems to be much more pronounced in Europe than in Asian countries.

The growing concern about risk and security issues as well as precautionary regulations can provide a positive as well as a negative climate for innovations and technological progress.

6.3.2 *Innovations for improvement and risk minimisation*

On the positive side, the preoccupation with risks gives incentives to develop improved solutions for old and suboptimal (e.g. pollutant, inefficient, insecure) practices and drives general developments towards a more preventative course. This tendency can be observed in almost all industries. The whole flourishing innovation fields of environmental- and safety technologies are the direct results of growing concerns over environmental risks and precautionary policy. Risk concerns are also adding a checking component to economic reasoning by implying that doing less harm can result in better payoffs. Also in the area of health, risk awareness has lead to an increasing interest in preventative measures, leading to new policies and technological innovations.

The demand for civil and military security technologies is also growing with internet and data security getting increasingly important. The cyber-attacks of 2007 directed towards highly internet-dependent Estonia have caused concerns all around the world, especially within NATO countries. These attacks may indicate a new era of warfare.

BOX IX: A sample of innovations linked to the 'Risks & Security' megatrend:

– Smaller, smarter, better and multifunctional surveillance technology
– Semantic technologies and Artificial Intelligence for surveillance and observation
– Privacy protection technology
– Improved sensor technology (e.g. bionic sensors)
– Advanced scanning technology (e.g. terahertz technology)
– Biometrics (e.g. multi-feature)
– Non-lethal weapons
– Advanced military technology (e.g. stealth technology, soldier protection and communication systems, new materials)
– Cryptography
– Explosives defusing technology/bomb-defusing and minefield clearance robots
– Forecasting technology/early warning & detection systems (e.g. for tsunamis)
– Social security reforms
– Preventative healthcare
– Counter technologies against NBC-weapons

6.4 Impact of the 'Risks and Security' megatrend

6.4.1 Perception of risks and opportunities

Risk perception and the interpretation of precaution can have a profound influence on people's choices and technological trajectories. Whereas in past times, many ideas could not be realised due to lacking technological capacities, today there seems to be a shift towards the opposite: humanity has the capacity for many technologies, which are not desirable to be realised. Risk concerns, risk assessment and its professionalisation affect all levels of society from international relations (e.g. global climate regimes and security issues) over individual countries (e.g. country-specific laws on threshold values or human embryonic stem cell research) to corporations (e.g. funding, grants for research projects and product evaluations) and finally individuals (e.g. available medical treatments, which may be based on risky R&D activities) who might be either exposed to certain risks or might be deprived of chances.

6.4.2 Ethical risks

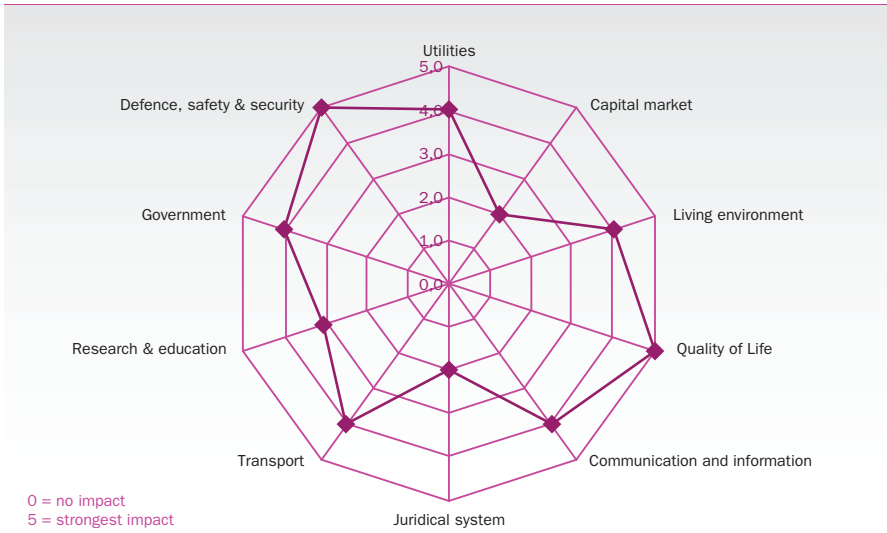
Whereas growing general consensus exists on risks associated with environmental pollution, physical harm and internet security, the risk evaluation over so-called emerging technologies that slowly begin to take form as realistic developments, which may lead to disruptive effects and especially comprise the areas of nanotechnology, biotechnology, cognitive science, robotics and Artificial Intelligence are still very controversial. The majority of policy makers and influential NGOs (e.g. Greenpeace, Friends of the Earth and ETC Group) are still taking a cautious stance in this regard. Above this, some innovations that may counter one risk, e.g. terrorism or age-related health problems, could in their course lead to other risks like hard-to-detect ubiquitous surveillance systems, hard-to-control Artificial Intelligence or so-called 'anthropotechnologies' (i.e. technologies that could alter human biological properties) are currently still controversial.

6.4.3 Balancing risk and precaution

On the down-side preoccupation with risks can also have an impeding effect on innovations, since by definition innovations are something new, no long-term experience exists which may conflict with the call for precaution. This is the case when the preoccupation with risks, rigid regulations and unrealistic calls for 'risklessness' are generating a climate of uncertainty, resignation, fear, innovation postponement and indecision. This situation generates a bias towards the status quo and against innovation. Other negative effects for innovation activities arise when risk assessment breaks free from a sufficient objectively accessible scientific basis (incl. distorting scientific facts) and becomes too long-term, complex and hypothetical or even politi-

cally motivated. When calls for precaution are becoming too strong, it may lead to a general aversion towards novelty and therefore a favour of the status quo. The line from healthy precaution to general 'neophobia' is thin. Above this, it has also to be kept in mind that the status quo – i.e. no innovation – may also bear risks.

FIGURE 24: Impact analysis of megatrend Risks and Security on different STN's



The Megatrend concern over Risk and Security issues of course has the highest impact on the STN's of defence, safety and security system and quality of life which will be confronted with new challenges. In general concerns over safety and security affect almost every area, whereas within different dimensions. In regard to defence it are mostly concerns over terrorism, national and international security, while in the area of transport it is about traffic and air safety. For communication the main issue lies in data security and protection and the area of quality of life can has many impacted dimensions ranging from risks to the food chain over uncertainties about social security, unemployment, pensions and the financing of healthcare to ethical question that arise with scientific and technological progress.

6.5 Background analysis of the 'Risks and Security' megatrend

6.5.1 The professionalisation of risk assessment

As a consequence of growing socio-technological complexity and increasing sophistication of scientific analysis, risk assessment has become more and more professionalised. Since the 1960s and especially the 1970s, a growing number of NGOs have established themselves to assess different risks like environmental risks, food safety and emerging technologies. Expert groups, testing agencies, ethic commissions, (interest-driven) NGOs and other (professional) individuals and institutions are competing in the domain of risk assessment and are acting in the interest of consumers, the environment or even humanity. The growing concerns over technological and human-made risks gained momentum in the 1980s and were fuelled by the Bhopal disaster in 1983 and the Chernobyl nuclear accident in 1986.

6.5.2 The burden of responsibility

The burden of responsibility has shifted more and more away from consumers and state actors to the industry and producers, who have to proof that their products are sufficiently risk-free. Governmental regulations in regard to safety and precaution have also become stricter at least in some countries (especially Germany) and certain areas (food, environment, industry, emissions). The European Union has widely adapted the so-called precautionary principle as guideline, which tends to get interpreted increasingly stricter. Some industries complain that too strict demands delay or even hinder innovative processes and that some risk-warnings are not sufficiently based on scientific facts. Critics on the other hand state that industries are primarily short-term and profit-oriented and therefore do not take into account potential long-term effects or complex relationships.

6.5.3 Shift in Accountability and Liability Issues

Another point to mention is the aspect accountability and liability. The accountability for accidents and mishaps increasingly shifts away from individuals (i.e. end users) and state actors towards manufacturers themselves. The shift of responsibility that has actually been intended for promoting the development of safer and better technology may also turn into the opposite. If exaggerated as it has been the case with many reliability lawsuits especially in the US, this changing perspective leads to uncertainty and hesitance in the industry and actually hinders innovations and improved product development.

On the other hand, technical products really become increasingly complex and build on a diverse array of actors and technologies (e.g. researchers providing the theories, programmers, diverse manufacturers of subsystems, human operators with machine/computer assistance), therefore making the clear determination of responsible entities harder.

6.5.4 *From natural hazards to ethical risks*

Today's concerns over risks are not only about immediate threats to human life anymore (e.g. car accidents, insecure building structures and war), but also include risks to remote environments (e.g. concerns over endangered species in the Amazon), future generations (e.g. germ line therapy) or humanity as such (e.g. 'anthropotechnologies[17]').

While environmental issues are already well established on the political agenda, it seems very likely that bioethical issues and controversies over the development of groundbreaking and promising but also possibly risky emerging technologies will soon add up as a new political dimension. Future concerns may not primarily be about not being capable of doing things, but about not doing the things one is capable of.

Levels of risk concerns:

RISK	EXAMPLES
External, natural risks	Earthquakes
Man-made hazards to humans	Dangers during factory work, construction, wars etc.
Man-made hazards directly affecting the environment	Air and water pollution, CO_2 emissions
Man-made activities indirectly affecting the environment negatively	Overfishing, excessive planting of energy crops
'ethical risks'	Human embryonic stem cell research, neurotechnology, biomedical engineering, privacy protection, 'anthropotechnology' (e.g. human enhancement technologies); here the risk may even lie in the *success* of the technology.

Due to increasing socio-technological complexity and technological novelties, risks, or at least uncertainties will grow. Uncertainties, especially about technological novelties will certainly remain, also because the amount of scientific and technical knowledge will continue to increase, a development that is very hard to stop.

17 Methods employed by humans for the purpose of human (self-)domestication. Defined as: "pharmaceutical and medical products, methods and strategies with the aim of enhancing and increasing human cognitive and physical performance or capacities" (ITAS, 2008)

6.5.5 *Concerns of the public*

Although environmental destruction as well as genetically modified food generate great concerns within European societies, European citizens generally have a rather optimistic stance especially towards environmental and information technology and even show a greater than generally expected support for biotechnology, nanotechnology, gene therapy and even embryonic stem cell research (if tightly regulated), because in their view the chances outweigh the risks (Eurobarometer 2005).

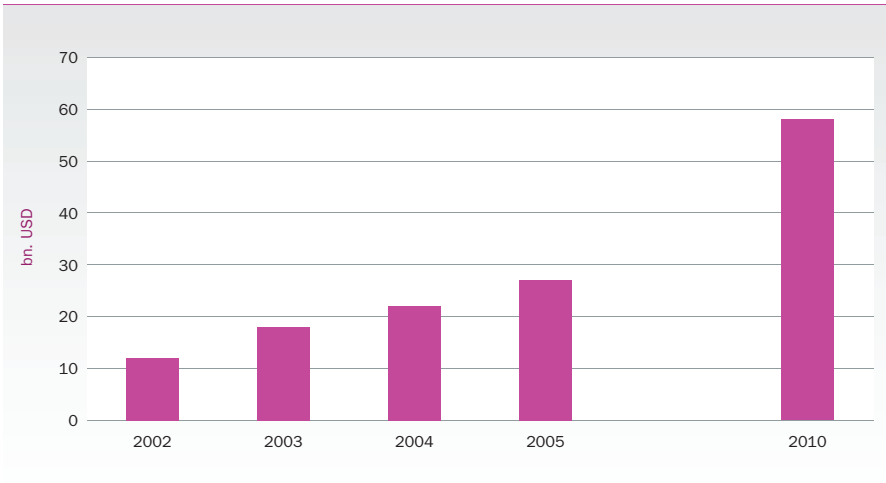
The major risk concerns of Europeans however are rather personal in nature. Although according to the June 2007 Eurobarometer survey, the personal concerns of Europeans are diverse and depending on the geographic and historical conditions, on average the main worries are about unemployment, rising prices for sustaining livelihood and old age poverty. Despite the huge governmental concerns, in June 2007 terrorism was only placed in the mid-range of issues that are considered most important for ones country (Eurobarometer June 2007). Rising food and energy prices not only worry individuals, but may also threaten the global economy and security (EurActiv, 2008). Also the current global financial crisis has lead to greater concerns over unemployment, income and pensions.

In regard to scientific and technological risk evaluation, human societies currently seem to stand on a crossroad with different paths to be taken. It may be possible that the global tendency will shift towards those countries that express less preoccupation with risks, since they provide a better climate for innovative R&D. On the other hand, a scenario where consumers rather opt against novelty out of fear over potential future risks is also imaginable by observing current developments where ‘natural’ and ‘less technology’ is often equalled with ‘less harmful’.

Although it is still disputed, what exactly influences individual risk perception (media influence, personal experiences, character traits etc.), in most cases the general public gets its information in a somehow pre-interpreted way over the media and NGOs, whereas especially the latter ones are very active in the area of risk assessment.

Fears about new technologies (e.g. genetic engineering), terrorism and risky Chinese products may be interpreted as a sign that technological and socio-political developments (e.g. globalisation and fading borders) are pacing ahead too far for the majority of citizens to comprehend and societies to adapt.

FIGURE 25: Global Internet Security Market



Source: BCC 2006

6.5.6 *Risks and emerging technologies*

The current controversies over so-called emerging technologies and 'anthropotechnologies' have not yet fully reached the general public and a wider spectrum of policy makers and the topics are still mostly discussed within expert groups. Public awareness about nanotechnology is still very low, but NGOs and consumer groups are already discovering the issue and are expressing growing concerns and risk warnings (NanoRisk 2008, ETC-Group 2008), which might lead to similar critical popular reactions as it has been the case with genetically modified foods and nuclear energy.

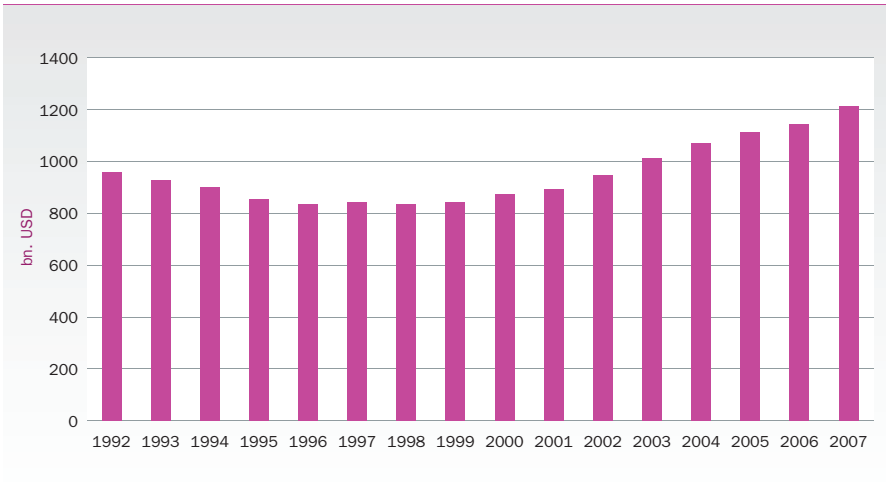
6.5.7 *Risk and globalisation*

The tensions between globalisation and national interests, the gap between rich and poor countries and strata within society as well as the diversification of life-styles and the growing confrontation with elements of unfamiliar cultures are likely to increase societal and political instability.

Also global political uncertainties are prevailing with growing fears about terrorism, a strengthening of Chinese and Russian power, instability in the Middle East and new countries obtaining nuclear technology with weapons grade potential. The global military expenditure has risen from 960 billion. USD in 1992 to 1214 billion. USD in 2007 (SIPRI 2008). As weapons may become smaller, smarter and more sophisticated, the assurance of security will become increasingly challenging. The global market for nuclear, biological and chemical (NBC) and explosive detection devices is expected to

grow from 1.7 billion. USD in 2006 to 3.5 USD in 2012 (BCC 2007). Terrorism may continue to remain a general topic, although it is likely to shift to a new level with attacks being focussed on a country's information infrastructure. This is a likely course, since attacking a countries information infrastructure may not even require costly materials and can be even performed from a safe distance at rather low risk for the potential terrorist.

FIGURE 26: Global Military Expenditures 1992 - 2007

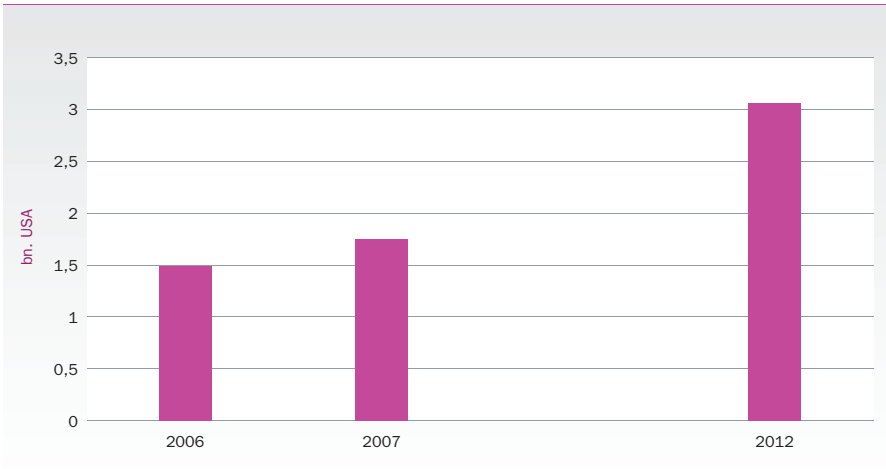


Source: SIPRI 2008

6.5.8 Responding to Disasters

Despite the increasing precautionary measures, natural disasters and man-made (large scale) accidents happen. In general local emergencies of larger scale have become more internationalized and interdisciplinary, although this depends on the local political situation. In some countries which are prone to certain natural disasters like earthquakes (e.g. Japan) and tornadoes (e.g. USA) or warfare and terrorist attacks (e.g. Israel), civil society is regularly involved in emergency response training. The global market for emergency response technology has amounted to 78.7 billion. USD in 2005 and is expected to rise to 104.3 billion. USD in 2013 (BCC Research 2008). Security und surveillance camera installation at public and vulnerable places has increased. Major disasters also get a great deal of international media coverage thus contributing to heighten public fears (e.g. about terrorism or plane crashes) and distorting risk perception.

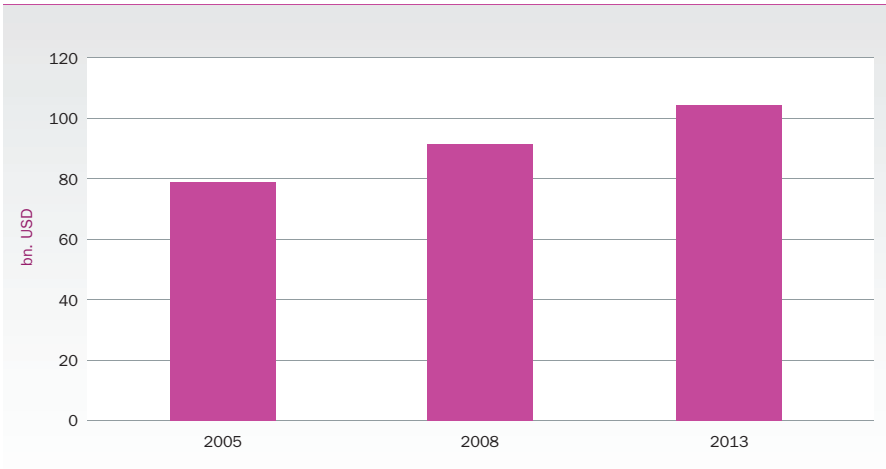
FIGURE 27: Global Market for NBC and Explosive Device Detection



Source: BCC 2007

Technological progress and innovation has contributed a lot to improving emergency response and disaster management. Mobile and fast information- and communication technologies, advanced sensor systems, improved logistics, water purification methods, protective gear, medical technology, robotics and artificial intelligence as well as computer simulations can be named as some of the most relevant advances. New technologies and innovations like computer simulations and the early stages of augmented reality are also becoming increasingly interesting for risk prevention, designing security systems or emergency response training.

FIGURE 28: Global Market for Emergency Response technologies



Source: BCC 2008

6.5.9 *Finding a healthy balance between risk prevention and innovation*

New methods of analysis as well as systemic and holistic approaches enable humans to imagine and investigate an increasing number of potential hazards, e.g. on the microscopic and sub-microscopic level, and possible interconnected implications. Although complexity and the possibility to detect potential hazards are very likely to increase in the future, it is far more a socio-political issue how to deal with this situation. Regulations have become increasingly stricter and thresholds (e.g. for contaminations) increasingly lower, especially in the areas of food, industry and traffic.

So far this led to a rising professionalisation of risk assessment and towards a greater preoccupation with risk and safety issues. In this regard, societies may be at risk of slipping from healthy precaution into fear-mongering, a tendency predicted by scholars like sociologist Frank Furedi who already speaks about the coming of a 'Fear Society' (Furedi 2006).

The challenge for the future lies in finding a healthy balance between risk prevention and the courage to try new ways and innovate.

6.6 Counter-developments stem from other problems such as energy or ethical risks

6.6.1 Discounting of future effects

As problems become more urgent, people generally tend to discount future effects. Rising energy prices have even made sceptical Germany more favourable towards nuclear energy and the global financial crisis begins to overshadow some environmental concerns. As the call for technological risk reduction and improved safety, security and precautionary measures increases, there may be fewer risky technologies around in the future that may cause profound risk concerns.

6.6.2 Embracing new technologies

In regard to controversies over ethical risks, there also seem to emerge trends directing towards mitigation. Countries that represent half of the world population already possess a permissive stance in regard to human embryonic stem cell research (Mbbnet 2008). Also the controversies over emerging technologies and even 'anthropotechnologies' are slowly beginning to normalise, paving the way for a more rational evaluation by focusing on feasible innovation capabilities and drafting practical legislation proposals. If positive potentials about novel approaches and technologies become visible, fears over risks, especially long-term and ethical concerns may slowly fade away.

The current emergence of two contrasting societal stances with growing influence, namely 'techno-progressivm' and 'bioconservatim'[18] can also be seen as an early warning signal for new controversies over future risks and technology management to come.

18 Technoprogressive actively support new and emerging technologies, innovations and scientific discoveries as long as they are sufficiently safe and practiced within a democratic and monitored frameset., whereas 'bioconservatives' hold a general sceptical stance about them due to uncertainty over (long term) risks, ethical or religious reasons.

5 MEGATREND

CHAPTER 7

THE NETWORK SOCIETY

Social networking, collective intelligence, web 2.0, web 3.0 and the internet of things.

7.1 The fast utilisation of ICT networks

The network society is characterised by the fast utilisation of networks to gather, exchange and exploit knowledge. The impact of the utilisation of information and communication networks in all domains of society and economy is tremendous. Knowledge – in all its forms – will become the most important factor of production. Exploiting knowledge – e.g. innovation – will become the most important asset, impacting on skills, learning capacities and societal structures.

The start of the network society can be pinpointed to the 1970s, with the Information Technology revolution, automatisation in offices and production processes and the subsequent rise of the Internet in the 1990s. The Network Society megatrend is expected to continue in future decades, in which the deployment of Information and Communication Technology will reach its full potential and will continue to impact and transform existing societal structures and institutions. The network society megatrend will induce new models for innovation, for conducting business, new operations and services of government, new models of collaboration, of learning and social interaction.

The future phases of the network society will include an increasing integration of physical and virtual worlds, resulting in the emergence of ambient and augmented environments. The networks will enable people to create and exchange information and knowledge in an instantaneous and continuous way, to collaborate with others in easy ways and engage more actively in all kinds of societal and economic activities. The development of more intelligent mobile wireless infrastructures will make social networking as ubiquitous as regular Web sites, creating tools to let virtually anyone create and use the new networks, to create new knowledge, media products, and to build and design their own worlds; tailored to their own customers, friends, fans or employees.

The explosive adoption of web 2.0 technologies is a first indication of how the web can be used as an innovative platform for data management, by harnessing the collective intelligence of users (O'Reilly, 2005). Semantic web technologies make it possible to automatically combine and interpret information from different sources and adjust information to personal needs and preferences. The emerging networks will connect humans to each other as well as humans to (computer) technology. It is here that the Network Society megatrend links to The Intelligent Age (see Chapter 8).

7.2 Link of the 'Network Society' megatrend with innovations

Innovation is becoming the dominant activity in society and its sources are getting more varied. The network society will change existing models of production as well as long standing business models. Also, the number of actors and type of actors involved in innovation is changing, e.g. innovation is being democratised by the network society. The democratisation of innovation is described by Von Hippel (2005) as 'users of products and services—both firms and individual consumers—are increasingly able to innovate for themselves'. Users will play an increasingly important role in the production and design of innovative services. This is already demonstrated by the active role of users in many web 2.0 applications. Extensive use of the Internet's capabilities will expand users' creativity and communication which enables users to create value for themselves (OECD, 2007). An example is the website sellaband.com, in which users can invest in a band's music. The revenues of a successful band could be shared with Sellaband, the investor-users and the band[19]. The active role of users in Sellaband is an example how the network society can drastically change production systems, organisational processes and existing business models.

Open innovation (first described by Chesbrough, 2003) is another example of how the network society changes the way innovation is organised. In the concept of open innovation, collaboration (instead of competition) between firms is considered essential to collect and exploit knowledge that is distributed over diverse networks. Information and knowledge will increasingly be co-produced. Benkler (2006) examines how ICT permits extensive forms of collaboration that may potentially have transformative effects on both society and economy[20]. New developments and concepts like crowd sourcing, mass collaboration, collective intelligence and wisdom of the crowds are first examples of such change. Firms will need to find different sources of knowledge to be able to continue to innovate. Innovation requires heterogeneity and diversity. With technological advances an individual's network can be increasingly socially and spatially diversified. Organisations can also benefit from the expansion of networks because having ties with different expertise can solve specific issues.

In this way, the network society does not only enable the creation of new innovative services, but also the creation of new innovation models. Furthermore, the future network society itself will also be an important driver and infrastructure for innovation through the fast utilisation of networks for the distribution of knowledge and creativity. This will enable people to collaborate in new ways as the examples of many open source software projects demonstrate. The network includes know-what, know-how and know-who. The future assets for government, firms and organisations will be the

19 For more information, see http://www.sellaband.com
20 http://en.wikipedia.org/wiki/Yochai_Benkler

speed by which the network(-s) are mobilised to utilise knowledge. It will lead to economies of scope and specialisation combined with economies of scale.

The technological developments in ICT, manifesting itself in the next stages of the internet, will provide a major challenge that will boost innovative activities regarding ultimate personalisation, context aware computing, social production of knowledge, safe and privacy friendly identity management, trustworthy networks and assessing the origin and trustworthiness of information.

BOX X: A sample of innovations related to the Network Society megatrend

– Software as service / Utility computing
– Grid computing
– Internet of things and smart devices
– Ambient intelligence / Ubiquitous computing
– Semantic web / web 3.0
– Trustworthiness of ICT
– Seamless ICT (interoperable and converging infrastructure, platforms and devices)
– Social software and social networking
– User created content / co-creation
– Mass customisation
– Open Innovation
– Crowd sourcing
– Identity management
– New business models
– Regulation for virtual worlds
– Innovations in the intellectual property regime
– Personalised media
– Life-long education and training
– Virtual economy
– Experience concepts
– Telecommuting
– e-democracy
– e-government

7.3 Impact of the Network Society megatrend

In general, the impact of this trend is relatively high in all domains. The impact of the Network Society trend is obviously in particular connected to the STN of communication and information, both as an object of and a driver for innovation. The networks enable fast and instantaneous communication, at any moment in time. The communication through social software and the next web will also invoke behavioural changes between individuals and groups and changes in language.

The Network Society is also expected to have a large impact on the Quality of Life domain. The active role of users in the network society gives users more control which enables them to exert a more direct influence on their neighbourhood, employers, firms and (local) governments to pursue their goals. Blogs and sites such as YouTube or WikiLeaks enable individuals to monitor government and firms' actions by reporting incidents online to a wide audience that previously might have gone unnoticed. This may vary from relatively small impacts, such as keeping the neighbourhood clean by reporting full trash cans on the streets online, to relatively large impacts, by influencing political campaigns. In general, the Network Society trend enables any group of users, including governments, to collect, analyse and manipulate large amounts of (personal) information in an easy and fast way to create value and new services. However, this development raises concerns for the ability for large and intelligent surveillance technologies that pose risks to the protection of individual privacy (see also counter-developments, Box III).

The network society also influences the juridical domain. The network society renders old organisational structures and formal institutions obsolete and requires the development of new social, economic and legal regimes (institutions). A clear example of this process can be found in the music industry, in which the emergence of the network society has profoundly impacted the way in which music is consumed (e.g. downloaded – legally or illegally in peer-2-peer networks) and the way that revenues are created. The ineffectiveness of the old copyright regime has created a spur of new regimes, such as digital rights management and creative commons licenses, which have had different successes.

FIGURE 29: Impact analysis of megatrend Network Society on different STN's

7.4 Background analysis of the 'Network Society' megatrend

7.4.1 The IT revolution as driving force for the emergence of a networked world

The term network society was first coined by Manuel Castells in "The Network Society" in 1996 in which he describes how communication networks have become the basic organising unit of society: "networks constitute the new social morphology of our societies, and the diffusion of networking logic substantially modifies the operation and outcomes in processes of production, experience, power and culture" (Castells, 1996, p. 500). Van Dijk (1997) defines the network society as a combination of social and media networks that shape its prime mode of organisation. According to UNESCO (2005), in such a society, traditional vertical hierarchies are giving way to horizontal and decentralised relationships, transcending traditional boundaries and borders (see also Megatrend of Fading Borders). The concept of network society builds upon notions Peter Druckers' knowledge society (1969) and Daniel Bell's information society (1973). The concept of the information society – as formulated by Bell – describes theoretical knowledge as the main axis of an information-led and service-oriented society. Benkler (2006) continues the impact of ICT regarding the networked information environment in his book 'The Wealth of Networks'.

The rapid pace of technological development, e.g. the Information Technology (IT) revolution, with its wide diffusion and application of information and communication tech-

nology (ICT) can be considered as the driving force for the emergence of the network society. The most important drivers include:

- Miniaturisation of micro-electronics leading to exponentially increasing capacity and multi-functionality of chips;
- Digitalisation of all data streams between components of tele-, data, and mass communication;
- Broadband transmission of data streams via new technologies (fibre, satellite).

According to Benkler, advanced economies have made two parallel shifts in the last century. The first move is to an economy centred on information (financial services, accounting, software, science), services (rather than manufacturing) and cultural (films, music) production. The second is the move to a communications environment built on cheap processors with high computation capabilities, interconnected in a pervasive network (Benkler, 2006, p. 3).

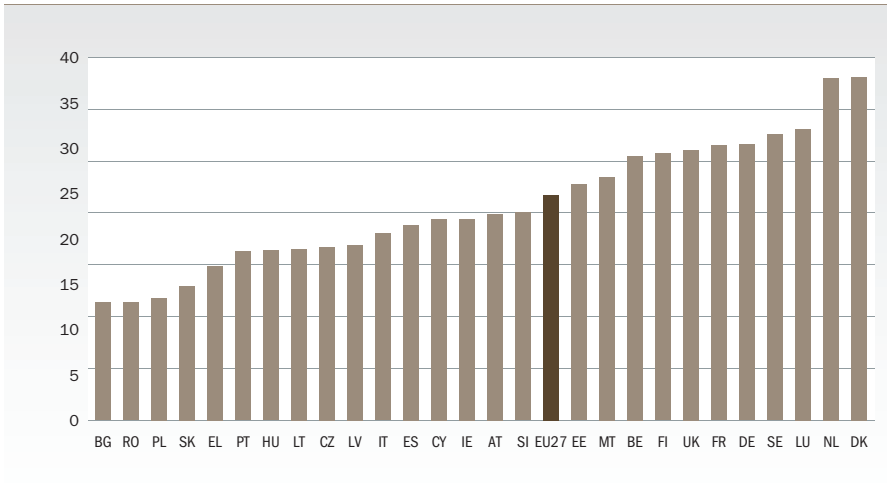
Through the emerging networks, the knowledge intensity of economic activities has increased and the marginal costs for manipulating, storing and transmitting information has dropped to virtually zero. The costs of innovation, prototyping and experimenting are low (Benkler, 2006). The application of knowledge to all aspects of the economy is being greatly facilitated by ICT, which has led to an acceleration of knowledge production. ICT has become an important driver of innovation in both manufacturing and services and has a positive impact on productivity at firm level (Leeuwen et al, 2009).

To handle the assessment and control of all available information, and more general, of the sheer complexity of post-industrial societies, new intellectual technologies are developed and implemented, such as cybernetics, game theory and information theory.

7.4.2 Increasing connectivity

One important underlying trend of the Network Society is increasing connectivity and growing capacities of the networks. This trend is clearly visible in the growth of broadband penetration (figure 30). The broadband take-up is considered an important factor for the emerging digital economy and competitiveness. In Europe, the number of households with a broadband connection increased. Furthermore, the average speed of broadband connections is growing rapidly, an increasing number of the European households have access to a connection of more than 10 Mbps (EC, 2009).

FIGURE 30: Broadband penetration in the EU



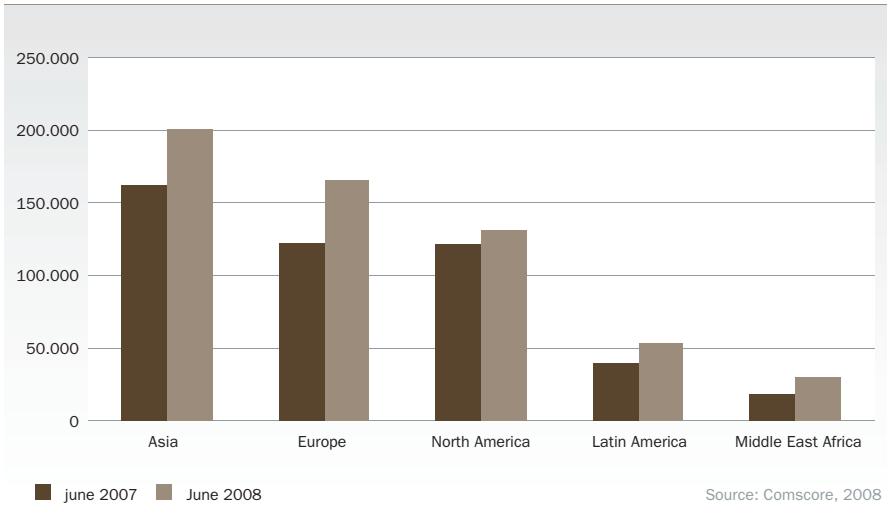
Source: EC 2009

7.4.3 The social web

The diffusion of broadband has brought about growth in a variety of online activities. Next to the online distribution of professionally-produced media content, such as music, films, video games and publishing content, the use of social software (including social networking sites, social bookmarking, sharing content applications etc. – also called web 2.0 or the participative web) has grown exponentially in the last decade, Social networking sites attract millions of users worldwide (estimated at 500 millions users in 2008). Figure 31 depicts the number of unique visitors of social networking sites in different parts of the world. Between 150.000 and 200.000 videos are uploaded daily to YouTube, growing to a total of over 80 million videos[21].

21 See http://mediatedcultures.net/ksudigg/?p=163

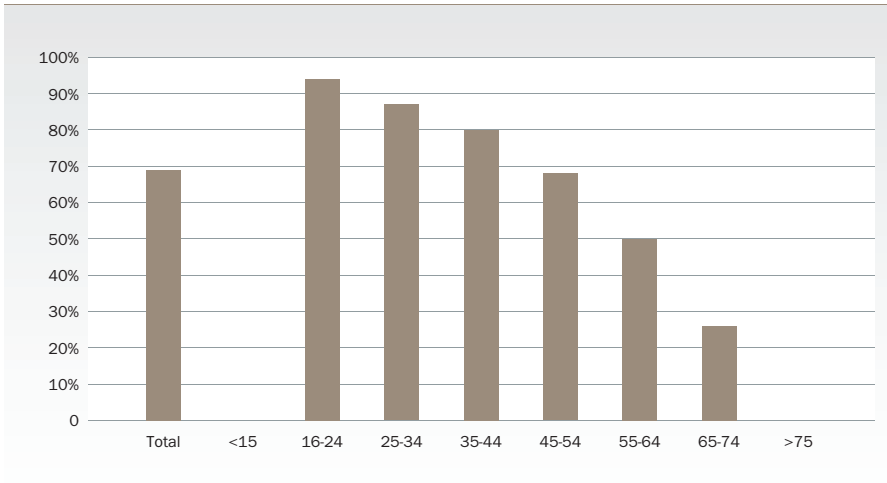
FIGURE 31: Number of unique visitors of social networking sites, per year (x 1000), June 2008



Source: Comscore, 2008

The instantaneous and continuous interconnectivity is likely to have a profound impact on younger generations. The 'digital natives' (born after the wide implementation of computers, networks and other types of digital technology) will be the first generation that will be completely familiar with the new opportunities of the network society. This is likely to result in new patterns of behaviour and new norms and values and cultural expressions. It might for example impact the way this generation will perceive the notion of online privacy (Kool and Frissen, 2008). Initial indications of such behaviour are already beginning to show. For example, they stand out as the most regular, intensive users of internet advanced services (EC, 2009). According to the Commission: "There is an evident, profound break with previous generations in the attitude towards the use of internet services".

FIGURE 32: Individuals who used the Internet in the last year



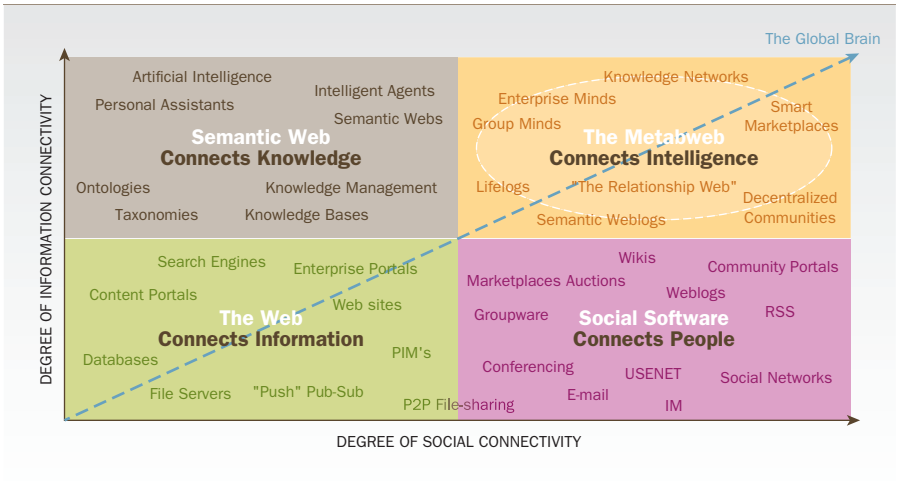
SOURCE: Eurostat Dec. 2010

7.4.4 The future of the web: web 3.0

Furthermore, there are also first indications of the emergence of the next web, also called web 3.0 or the semantic web. Applications start to emerge that allow users to add metadata to online information, which makes it more accessible and searchable by machines. For example, Facebook started their Open Graph search protocol in 2010, which has a semantic element in it. Google acquired in July 2010 a semantic search company Metaweb[22]. Such metadata could change the way we interact with the internet. Metadata allows computers to 'understand' information, which results in a better and faster interpretation and management of information. This is expected to provide a new boost in service delivery.

22 http://www.newscientist.com/article/mg20727715.400-google-twitter-and-facebook-build-the-semantic-web.html

FIGURE 33: Future development of the Web



SOURCE: Nova Spivack/www.mindingtheplanet.net

The Network Society is likely to generate impact on different levels of societies and economies. We will describe three dimensions: the impact of the network society on government, on firms and organisation and on the individual. We conclude this paragraph by describing on which STN's the Network Society Megatrend has the most profound impact.

7.4.5 *Networked government is interdependent and loosing control*

The globalisation of economic activities, media and electronic communication on the one hand, and of crime or social protest on the other, might undermine the instrumental capacity of the nation state. The nation state is increasingly challenged in controlling monetary policy and budgets, in organising production and trade and in fulfilling commitments to social benefits. The state is becoming interdependent within a broader network of economic processes that are no longer fully under control of government. Effective government action will increasingly require the mobilisation of networks connecting national and local governments, private companies and non-profit organisations across different sectors. It will require interaction and cooperation between different governmental agencies (belonging to different ministries) and increased interaction (through consultation with and engagement of citizens) with citizens to be able to act and react timely and accurately. Decentralisation – throughout all government organisations – is considered as a way to increase flexibility and to make government action more responsive to the needs and demands from different organisations in society. Securing trust, privacy and confidence in online networks will

be important challenges for policy makers in order to facilitate the continuous and optimal use of networks.

7.4.6 The Networked organisation is dependent on the exploitation of knowledge

The exploitation of knowledge (e.g. innovation) becomes the most central theme in the network society. In an economy that is shifting to services, there is a transition from goods production to the provision of services. The smart use of social software and tools and the modernisation of knowledge infrastructures become more important for organisations. This will require changes in organisational structures, which still operate in distinct organised groups, but are becoming less hierarchical and more ad hoc based. The organisation in the network society is mainly bottom-up based, more organic and less hierarchical and structured, facilitating inward and outward cooperation.

The knowledge production system is becoming more widely distributed across a host of new places and actors. Users and 'lay people' become also sources of innovation (besides formal and applied research and development) (Von Hippel, 1988; 2005). Research and development are internationalised and networked. As knowledge has become widely distributed, companies can no longer afford to rely entirely on their own (knowledge) resources, and are forced to find new cooperation and competition patterns. More and more, organisations will need to cooperate with other organisations and knowledge institutions to exchange knowledge and to buy or licence patents. The concept of open innovation in cooperation patterns needs to be elaborated. A company's invention can be shared with others through joint-ventures or spin-off companies.

Another challenge for the future networked organisation is to continuously increase its productivity. There will be an increasing need for flexibility and individualisation of labour. The organisation is more dependent on skilled employees. The networked worker or employee will be a part of the networked labour and focus more on entrepreneurship while applying subcontracting.

7.4.7 Networked individual is attached to virtual social networks

In a relatively short period, social networking is being used by the masses (in advanced economies). This creates new ways of exchanging and sharing information which will change our communication behaviour. Social networking is expected to influence social contacts, collaboration and learning. Virtual worlds are gaining importance in our daily lives and create a fluent mix between online and offline spaces.

New technologies (e.g. RFID, sensor networks, satellite navigation systems which enable personal location based services) will altogether lead to interwoven physical and online worlds, i.e. mixed realities.

According to Castells (2002) a shift has occurred from a society traditionally organised in groups (defined by geographical borders and real-life/offline communities) to a society based on networks. The individual (rather than societal groups) has become the node of society. The new social pattern is no longer limited to the 'physical togetherness' of groups, but is defined by the communication through networks at different locations and times. Information and communication technologies (ICT) ensure the 24-hour availability of the individuals in the network. Individuals can choose their mode of communication, and accordingly, their degree of sociability.

Individuals can (and especially young people e.g. the 'digital natives' do) experiment with their identities online through social networking, virtual worlds and other online services (Valkenburg et. al., 2005). This enables a kind of freedom that could never be experienced in the real physical world, but might also result in having too many identities and a possible loss of ones own identity – with yet unknown consequences. It actually raises the question of 'what is identity'.

7.5 Counter-developments

From a technological perspective, the Network Society trend may be considered irreversible. This development is expected to be mainly driven by the adoption speed of future innovations concerning web 3.0 technologies and beyond. Important forces that may influence the speed of development of the network society are:

1. **From a social/cultural perspective**: the loss of trust and common fear concerning the loss of privacy, identity, (personal) data etc. caused by major (criminal) abuse or incident(s), driving internet users back to the offline, physical world;

2. **From a political point of view**: damage to vulnerable vital infrastructures ('digital paralysis') either by 'natural' causes or intentional causes (such as cyberware, cyberterrorism);

3. **From a technological point of view**: the artificial creation of virtual borders within the internet to restrict unlimited access (for example using IP numbers as identification to grant access to multimedia).

6

MEGATREND

CHAPTER 8

THE INTELLIGENT AGE

The creation of intelligent artefacts, human enhancement, converging technologies and the engineering of nature

8.1 Bits, brains and biosystems

The 'Intelligent Age' goes beyond the 'Network Society' and describes the possibilities that scientific and technological developments in the fields of nanotechnology, biotechnology, ICT and cognitive science are about to create. In this field, biology is purposefully being modified and intelligence of humans and artefacts is (artificially) enhanced. Artificial Intelligence (AI) is improving and is gaining more and more human capabilities. Human intelligence is being augmented by computer technology. Humans may even fuse with their technology in a profound and physical way. An information-based world view is the core to these developments where DNA is treated as an information molecule and the human brain as one sort of information processing and storage unit. This enables the treatment of biological entities in a similar way as computer hard- and software and with it the fusion of these concepts.

While the further miniaturisation of microchip technology is already leading ICT from micro-technology towards nanotechnology, neurotechnology and biotechnology are also playing an increasingly important role in computer technology and AI. Research projects like the 'Blue Brain' project conducted by the Ecole Polytechnique Federale de Lausanne (EPFL) with the aim of 'reverse-engineering the mammalian brain' in a computer simulation[23] as well as the FACETS project that attempts a hardware modelling of biological neurosystems[24] are some of the most advanced examples in this regard so far. Already in 2004 scientists succeeded in utilising rat brain cells to control a flight simulator[25] and brain computer interfaces (BCI) have become more widely used in humans since the beginning of the 21st century with the gaming industry finally brining non-invasive devices onto the market for controlling computer games around 2008[26]. BCIs, power enhancing exoskeletons[27] and cybernetic implants are already proof for the fusion of computer technologies and biology and the feasibility of so called 'cyborgs'. While robots and AI are beginning to show more and more human traits and get increasingly better in pattern recognition (e.g. in recognising faces, speech, handwriting and contexts), humans already emerge making ICT an integral part of their bodies or at least of their actions.

23 http://bluebrain.epfl.ch/
24 http://facets.kip.uni-heidelberg.de/
25 http://dsc.discovery.com/news/briefs/20041018/brain.html
26 http://www.thinkartificial.org/machine-interfaces/first-consumer-brain-machine-interface/
27 http://www.engadget.com/2009/04/11/cyberdyne-said-to-be-mass-producing-4-200-hal-robotic-suit/

8.2 Self-guided evolution

Biological development also no longer needs to rest on the chance-driven process of natural reproduction and selection. Due to the ability to modify the DNA of biological systems – the information that guides their development – organisms can be modified in order to display specifically wanted traits and even totally new ones can be created. The new field of synthetic biology has the goal to engineer (micro)organisms that do not naturally exist in order to solve certain problems like eliminating contaminations or producing fuels. In May 2010 researchers at the Craig Venter Institute developed the first bacteria cell being controlled by a synthesized (i.e. artificially engineered and not naturally occurring) genome[28].

The 'Intelligent Age' - with its goal of improving the intelligence of humans and artefacts - is also causing controversies in the context of so-called human enhancement technologies (HET), which is reflected in the European criticism of the US Initiative on Converging Technologies (HLEG 2004, Coenen 2008). The European view on converging technologies is expressed in the document "Converging Technologies for the European Knowledge Society" (CTEKS) and emphasizes the notion of "engineering for the human mind and body" (cf. HLEG, 2004) as opposed to the US report "Converging Technologies for Improving Human Performance" that speaks of the "engineering of the human body and minds" (cf. Roco/Bainbridge, 2003[29])[30]. This leads to a growing polarisation between different stances and interests and may even create a new future (bio)political conflict line which runs lateral to the classic 'left-right' division (Hughes 2004). Therefore especially the megatrend of the Intelligent Age can serve as an example for the interlock between the possibly conflicting parts of technology-driven and society-driven forces that will determine the trajectory of this trend. The CTEKS scenario is likely to result in smart assisting technologies (e.g. ubiquitous computing, semantic translation devices), whereas the US Convergence Scenario has a stronger focus on human augmentation and 'cyborg' technologies (Bainbridge/Rocco 2003). Asian scenarios, especially from South Korea and Japan imagine robots that become increasingly integrated into society and look even human like (Leis 2006, New York Times Online 2006, National Geographic 2006).

28 http://www.sciencemag.org/cgi/content/abstract/science.1190719
29 http://www.wtec.org/ConvergingTechnologies/Report/NBIC_report.pdf
30 Cf. also the presentation by Elie Faroult (European Commission) www3.unitn.it/events/consci/download/presentation/Faroult_2.ppt

8.3 Link of the 'Intelligent Age' megatrend with innovations

Two major developments are key to the development of the Intelligent Age:
1. the further development of AI and computer technologies and
2. the convergence of different R&D areas, namely nanotechnology, biotechnology, information technology (AI and robotics) and cognitive science and technologies (neuroscience and technologies) – commonly referred to as the NBIC convergence.

Computer technology can be regarded as a key enabler for these developments and without it, no modern biotechnology, neurotechnology or nanotechnology would be possible. But now scientific and technological advances have reached a point where the inputs from other disciplines are getting increasingly interesting and important and are leading mutually spurring each other's progress and developments. This cross-fertilisation of different disciplines that possess many common elements but also complements can initiate real innovations. This could have unprecedented impacts on the future of health, quality of life, information processing and exchange and the relation between humans and their artefacts and other areas.

In several scientific disciplines research and development will have major impact on future innovations, such as:[31]

Advanced Artificial Intelligence and Robots
Advances in Artificial Intelligence (AI) and robotics are progressing, although it is still disputed if AI will ever be able to achieve human capabilities in some areas. Nonetheless AI systems and robots already outperform humans in many tasks, especially those that are related to fast data processing and precision. Advances are also being made in pattern recognition (e.g. faces, handwriting), speech and semantic technologies and the application areas of robots are growing.

Cognitive science, neuroscience and robotics
Our interest in and possibilities of understanding the (human) brain are growing constantly and we may be on the way of entering the age of neuroscience and neurotechnology. As our possibilities to understand and manipulate our brain will grow and technologies like self-learning systems or the possibility to modify ones cognitive functions and abilities could emerge, new and important legal, social, ethical and even personal issues will arise. Cognitive science and robotics/AI are also increasingly influencing each other.

31 the first four innovations have been identified as key technological requirement for the realisation of Ambient Intelligence (EC, 2001)

'BioShift' concerning a variety of issues originated in biological science, such as: biotechnology (combining disciplines like genetics, molecular biology, biochemistry, embryology and cell biology incl. genetic engineering), bioinformatics (incl. artificial neural networks, DNA computing, "Blue Brain Project") on the one hand, and a growing interest in so-called "biological" food (i.e. organic / natural grown food; non-GMO), biofuel, biodegradable, biomaterials (environmental issues) but also bioterrorism, biohazards or biosafety on the other.

Medical technologies and biomedical engineering (e.g. BCI, prosthetics, tissue engineering, biosensors), biomimetics or bionics, ICT implants (e.g. bottom-up AI, robotics, under development). Bionics is the application of biological methods and systems found in nature in the design of engineering systems and modern technology. Examples in the medical field aim to restore or reconstruct specific human functions, including artificial hearts, bionic eyes, ears, limbs etc. More generally, applications range from artificial "shark-skins" that reduce air resistance and fuel consumption in airplanes to the creation of artificial organs and body parts.

Human Enhancement Technologies as new science and technology-based possibilities to improve human physical, cognitive and psychological capabilities do already exist and are being tried out. As the scientific and technological advances may become greater in the future, even more sophisticated and profound modifications may become possible. This not only includes biotechnology and cybernetic devices but also life extension and neuro-simulations that are more advanced than the EPFL Blue Brain project.

Nanotechnologies

Computer technologies (e.g. 'micro'chips) are already becoming increasingly smaller, reaching what is defined as the nano-scale. Nano-scale engineering is also an important element of modern material sciences and the fusion of nano with biotechnologies is under way. Nanobots do not sound that far-fetched anymore as basic components like gears[32] and energy devices[33] have already been developed and the idea of (medical) nanobots gets serious scientific backing[34].

32 Also see http://www.physorg.com/news139066118.html and http://www.nature.com/nmat/journal/v8/n7/abs/nmat2467.html

33 http://www.technologyreview.com/energy/22118/?a=f

34 http://www.3sat.de/mediathek/frameless.php?url=/nano/gesellschaft/144378/index.html

BOX XI: A sample of innovations linked to the Intelligent Age megatrend:

– Advanced prosthetics and ICT implants
– Regenerative medicine and tissue engineering
– Self-assembling and self-replicating technologies
– Artificial organisms
– Non-industrial robots/home robots/ care robots/ military robots etc.
– Nootropic enhancement technologies
– Gene therapy (beginning)
– Neurosimulations

Possible future technologies
– Nanobots (e.g. in the context of medicine or surveillance)
– Smart dust (networked sub-micron or nanoscaled sensor or robot systems e.g. for surveillance)
– Life extension technologies
– Artificial General Intelligence ("strong AI")
– Artificial chromosomes
– Advanced human enhancement technologies
– Supersoldiers
– Whole brain simulation/emulation

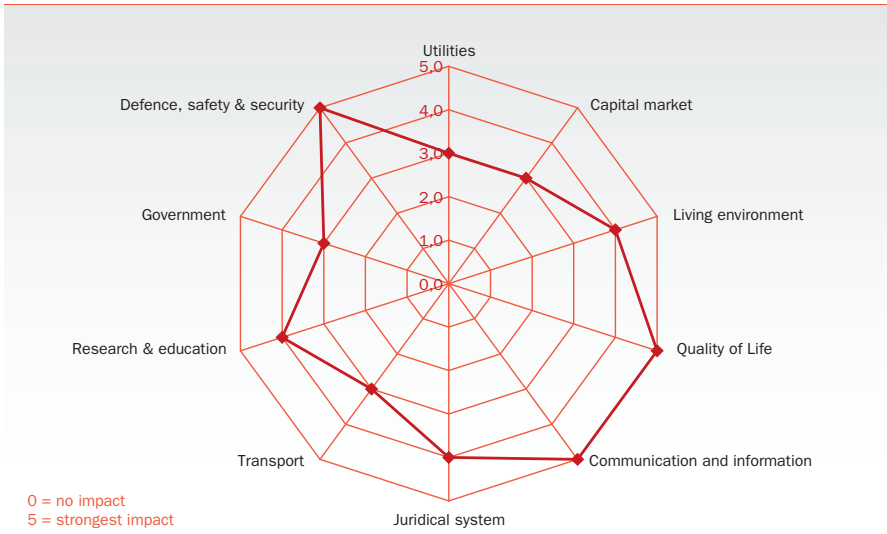
8.4 Impact of the 'Intelligent Age' megatrend

These future developments originated in several scientific disciplines will create all kinds of innovations that will shape the nature of future lives.
The fuse of information and life sciences could transform our way of life more fundamentally in the next few decades than in the previous thousand years (Rifkin, 1998).

Converging technologies will bring about many new applications integrated in objects, environments and connected to the human body and mind, influencing and improving our body functions and health as well as our living environment. They will also bring about smart housing and mobility concepts.

Intelligence as a property of humans and objects (and hybrid entities of both) will be the central aspect of a future society and economy and serve as a global enabler for finding solutions in a growingly complex world. Robots with increased autonomy and human-like features, materials that react towards their environment, self-assembling artificial structures, self-correcting computer programs, artificial organisms and even 'cyborgs' are already becoming reality. Whereas by some the coming of the 'Intelligent Age' is heralded as a very important step in human history, it is by others as posing grave and unpredictable risks (cf. Fukuyama 2002; Roco/Bainbridge 2002; Kurzweil 2005; Coenen 2008).

FIGURE 34: Impact analysis of megatrend Intelligent Age on different STNs



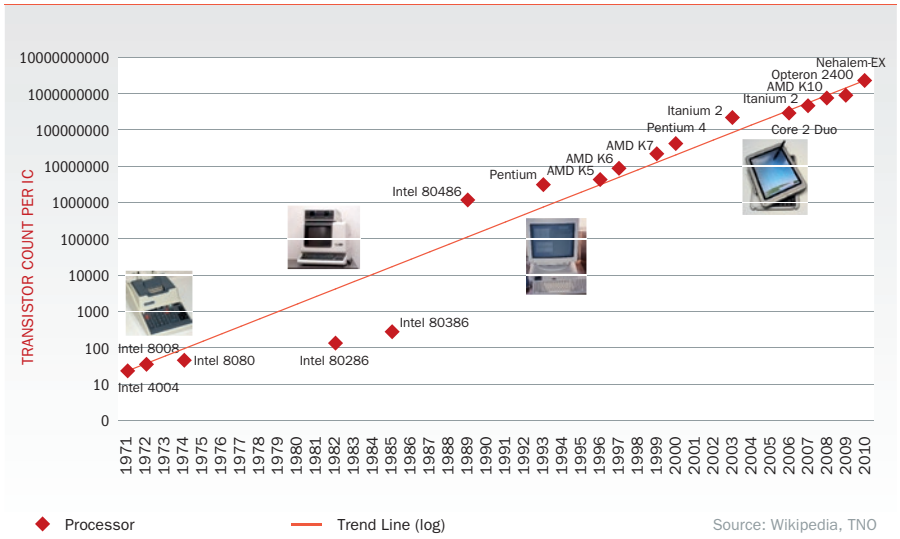
As figure 34 shows, the impact of the megatrend Information Age is the largest in the Quality of Life domain, including new possibilities and changes in personal health, healthcare and also comfort and easiness in the way we organize our lives. The impact of the megatrend in the domains of Defence, safety & security, concerning new ways of attacks and defence and on the Living Environment is also quite high.

8.5 Background analysis of the 'Intelligent Age' megatrend

8.5.1 The prospects of Artificial Intelligence

There are different prerequisites that are necessary to enable the 'Intelligent Age' of which many look achievable at least to some extend. In regard to computer processing speed, further improvements with current transistor design are expected to continue until 2020, at least according to projections based on Moore's Law. After this, it is expected that current microprocessors will reach physical limits in regard to the density of integrated circuits (Silberglitt 2006). It is still unclear in how far emerging computing concepts like DNA computing or quantum computing will be able to be competitive and solve the problems. Some, although disputed experts like Ray Kurzweil (2005) predict, that by 2020 a $1000 desktop computer may reach the raw processing power of the human brain.

FIGURE 35: Visualisation of "Moore's Law"



However raw processing power still does not say anything about intelligence and inefficient software design may use up unnecessary processing resources.

But real AI also makes progress, especially in the context of pattern recognition, an area where humans and even animals were much better than machines for a long time. Recent examples for improvements in this area can be seen in software for solving so-called CAPTCHAs – short for Completely Automated Public Turing test to tell Computers and Humans Apart. This requires humans to solve visual/textual and in recent times semantic puzzles in order to ensure that a human and not a machine (e.g. spam bots) is entering information on websites. However latest software can already decipher around 60% of visual/textual CAPTCHAs and another one is able to tell dogs and cats on a picture apart with a success rate of 83% (Technology Review 2008) . The use of distorted letters and numbers are being used increasingly less frequent and replaced by semantic questions because the software has become too good at the task and humans already begin to have increasing difficulties of deciphering the images. CAPTCHAs are becoming more complex as software improves. Semantic software is developed with the aim to mimic an understanding of the data it is processing. The latest Artificial Conversation Entities (ACE) already fools 25% of humans who wrongly think they chat with a human instead of a computer program (Science Daily 2008). The use of computer technology is now being transferred to a new level, which does not only focus on information distribution, but on intelligence. For creating real AI, however, much more has to be learned first about the information processing in living organisms and ultimately humans.

8.5.2 Info-Cogno-Convergence

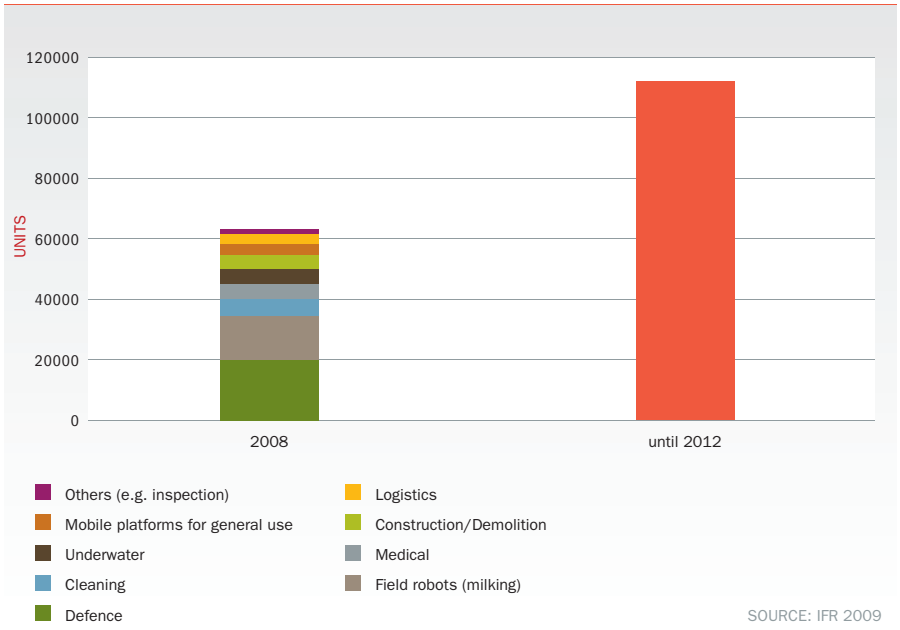
Cognitive and brain sciences are getting increasing attention, especially from scientists who research on dementia, but also from AI researchers. New computer- and imaging technologies are enabling better analysis of the human brain and new insight of brain sciences are used to improve AI. The boldest project so far may be the "Blue Brain" project initiated by the Lausanne École Polytechnique and IBM in 2005 with the final goal of producing a computer simulation of a neocortical column (of a mouse or rat). The results are thought to provide important insights for understanding forms of dementia – and as a side effect maybe new insight for improving AI. Computer technology is already fusing with the human brain. And already in 2004 rat neurons in a Petri dish were utilised to steer a flight simulator (Discovery Channel Online 2004). Most research on so-called Brain-Computer Interfaces (BCI) focuses on developing new ways of expression for disabled people. Recently it has been shown that BCI can also be used in games to give users a richer experience and new ways to interact with a computer or game console.

8.5.3 New robots and humans

Robots are becoming more intelligent and versatile and are thus being utilised within a growing number of application areas outside the "classic factory halls" which includes the military, offices, hospitals and even private homes. According to the 2009 report of the International Federation of Robotics (IFR), a total of 63000 service robots for professional use were sold until the end of 2008. The number of service robots for personal and private is estimated to be about 4.4 million units with 2.8 additional units for entertainment and leisure use as of end of 2008. Projections for the period of 2009 to 2012 estimate 49000 new installations of service robots for professional use during this period. 11.6 million service robots will be sold for personal use and 6.8 million for leisure and entertainment within this timeframe (IFR, 2009)[35].

35 http://www.ifr.org/service-robots/statistics/

FIGURE 36: Figures (estimated) robot sales



Artefacts are becoming more human-like/life-like and intelligent on the one hand, while humans are about to fuse with their technologies on the other. Humanoid robots, the emerging semantic web, software and hardware designs that are based on the workings of biological systems and self-assembling artefacts are some examples for the former, while wearable computers, augmented reality systems and intelligent prosthesis and implants are examples for the latter. The growing blurring between living and non-living entities and between humans and machines is already causing ethical disputes and raises questions about the definition of being human (cf. Fukuyama 2002, Naam 2005; Leis 2006). The South Korean government on the other hand is in the progress of drafting a code of ethics to ensure human safety at the presence of robots and prevent robots and androids being abused by humans. This is especially relevant as South Korea plans to put a robot in every household by 2020 (National Geographic Online 2007).

8.5.4 Real Cyborgs

The first implantable device was the pace maker introduced in 1960, followed by systems for bladder stimulation. The most recent examples are active implants like drug delivery pumps (such as insulin pumps for diabetes), neuro stimulation devices (for example to restore grasp function) and deep brain stimulation to treat patients' psychological disorders and trembling caused by Parkinson's disease (EC, 2005). Current

applications include medical records and healthcare information (such as blood type, potential allergies and medical history) or identity management[36]. Furthermore, wearable or implantable devices, e.g. subdermal GPS personal location devices have been developed to track someone's position worldwide. For example, affluent Mexicans worried by soaring kidnapping rates are spending thousands of dollars to get themselves tiny transmitters implanted under their skin to enable satellites to track and find them even if put in the trunk of a car[37].

Implants to restore vision to the blind are about to be approved by regulators and being marketed and Brain-Computer-Interfaces (BCI) allow tetraplegics[38] to control computers and robotic manipulators through readouts of brain functions. The cybernetics professor Kevin Warwick had himself implanted a tiny microchip that enabled him to control his institute's office infrastructure back in the late 1990[39]. Millions of people already live with electronic and mechanical implants today, thus having made the "cyborg" already a reality. However, future technology could go even further by enabling the fusion of biology and computer technology not only for use as prosthetics but also for enhancement purposes (i.e. the improvement of physical, cognitive and psychological capabilities of healthy human individuals).

8.5.5 Human Enhancement Technologies

Latest research efforts even aim at finding ways to enhance human cognitive, physiological and psychological capabilities on the basis of scientific research and technological applications, which also includes the slow-down of aging processes. Neurotechnologies to assist the disabled or counter neurological disorders as well as efforts being made in tissue engineering, regenerative medicine, advanced prosthetics and gene therapy are already paving the way for potential applications that may go beyond therapeutic use, i.e. human enhancement technologies.

Also pharmaceuticals and neurotechnologies that have originally been developed to cure diseases (e.g. Ritalin as a medication for ADHD, Modafinil for the treatment of narcolepsy or transcranial magnetic stimulation[40] against depression) are also already being used by healthy individuals in order to improve cognitive functions (e.g. concentration, wakefulness, focus). With possible future advances in technology, brain com-

36 In the Baja Beach Club in Barcelona and Rotterdam, the chip serves as a smart card to speed up entry into the club and payment of drink and entrance

37 http://technology.newscientist.com/channel/tech/dn14589-mexicans-get-microchipped-over-kidnapping-fears.html?feedId=online-news_rss20

38 paralysis of the arms, legs, and trunk of the body below the level of an associated injury to the spinal cord.

39 http://www.kevinwarwick.com/ICyborg.htm

40 Transcranial magnetic stimulation (TMS) is a noninvasive method to cause depolarization in the neurons of the brain, making use of electromagnetic induction

puter interfaces, microchip (brain) implants[41], genetic technologies or even nano-sized devices ("nanobots")[42] may also be used to enhance human capabilities.

8.5.6 *Artificial nature and natural artificiality*

Biotechnology is already transforming agriculture, medical diagnosis and treatment as well as animal and maybe even human reproduction. Most recently, the transformative potential of nanotechnology has also captured the imagination. Adding to this, cognitive- and neurosciences are challenging the way how we think about ourselves and 'smart' objects. The borders between hardware, software and wetware (i.e. biological systems and biological brains) are blurring. Concepts like self-assembly and neuronal networks taken from biology are already being explored in hard- and software design. Smart materials which closely represent Gershenfeld's vision of 'intelligent objects' (Gershenfeld 2000) show characteristics like the ability to react towards their environment, which have been previously exclusive properties of living organisms. Improved and cheaper computing power is also a key enabler for advances in neurosciences (e.g. Blue Brain Project) and biotechnology (e.g. DNA sequencing).

Another example is DNA-sequencing. While the first project to sequence the total genome of a human being (Human Genome Project) which started in 1990 and took over 13 years to complete and cost 10 mio. USD, in 2007 it took Leiden University (Netherlands) researchers only 6 month to sequence the whole genome of the first female at a cost of 40000 USD (Cell News 2008). A California-based company aims at sequencing a total of 1000 human genomes for $5000 each in 2009 (Bio-Medicine Online 2008). So computers help humans understand life and concepts taken from nature help to improve computers. It is assumed that, through their mutual complementation and enhancement, converging technologies could lead to new and innovative solutions to solve a multitude of problems and lead improvements for the quality of life and the human condition (In 't Veld et al. (eds.) 2007).

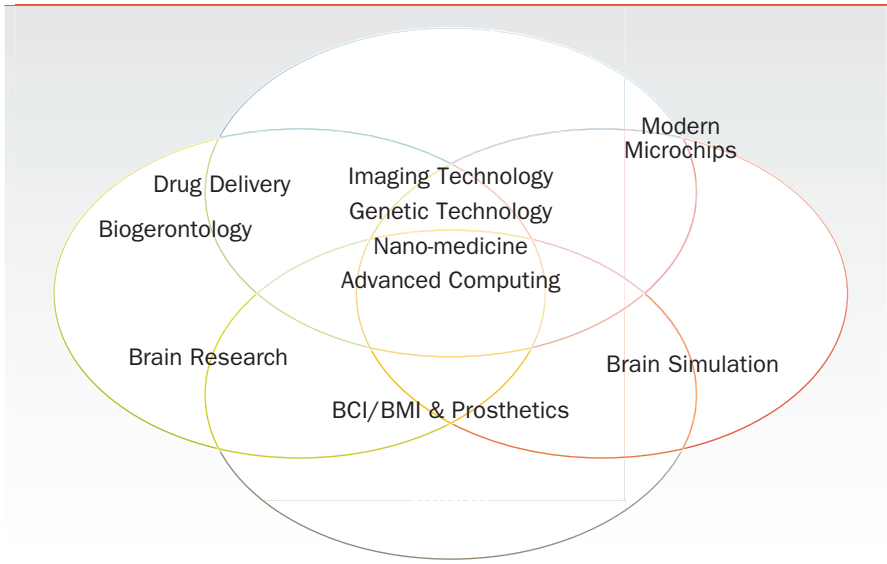
8.5.7 *Converging Technologies*

Biotechnology, information and communication technology, combined with nanotechnology and high tech materials are already starting to converge, giving rise to new applications and possibilities (Verlaan, 2007). Although the notion of the so-called convergence of technologies, namely nanotechnology, biotechnology, information technology and cognitive sciences (abbreviated as NBIC-Convergence) is still disputed by some (e.g. Coenen, 2007[43]), some pragmatic elements of a tendency towards conver-

41 http://viterbi.usc.edu/news/news/2009/viterbi-school-team.htm
42 http://electronics.howstuffworks.com/nanorobot.htm/printable
43 http://www.itas.fzk.de/deu/lit/epp/2007/coen07-pre01.pdf

gence seem to be obvious. Such developments towards convergence are visible within the merging of nanotechnology and ICT in regard to further miniaturisation of 'micro'processors, the fusion of neurones with microchips as well as brain computer interfaces, neurosimulations and disciplines like bioinformatics, early developments towards 'nanobots' by merging biology with nanotechnology and the disciplines of nanobiotechnology and bionics.

FIGURE 37: Merging of technologies



8.5.8 Accelerating progress?

The megatrend of the 'Intelligent Age' is very much science and technology-driven and depicts many things that are and could be technologically possible. This had lead to the idea of the so-called 'Technological Singularity' that has been introduced by the futurists Vernor Vinge and Ray Kurzweil in the 1990 and has gained much controversy and attention within the foresight community and beyond since the late 2000s[44].

Although there does not exist a clear and common definition yet, it is actually an extension and generalisation of the so-called Moore's Law that predicts the exponential growth of some key properties of ICT, the 'singularity' is mostly described as: "The Singularity is a theorized future point of discontinuity when events will accelerate at

44 E.g. World Future Society (http://beta.wfs.org/node/1146) and http://www.wfs.org/may-june09/vassar%20page.%20.htm

such a pace that normal unaugmented humans will be unable to predict or even understand the rapid changes occurring in the world around them."[45]

However, the methods being used for these predictions seem to look at trajectories how they might develop under ideal conditions without accounting much for societal, political, legal, economic and ethical factors that could significantly impact trends of technological progress and development. Nonetheless science and technology are progressing at a pace where society, politics, legislation and administration find it increasingly hard to catch up. Decision-making about trajectories that could impact humanity and pose new questions for ethics, law, the economy and other dimensions needs to become faster and more anticipatory. However, society will be the final decision-maker in how far these possibilities will be implemented and which developments and ideas get more support or less.

In any case the prospect of the 'Intelligent Age' draws much controversy over the desirability of the possibilities that are likely to be opened by current and future research, development and technologies in neuroscience, robotics and AI, biotechnology and nano-scaled engineering.

8.6 Risks and counter-developments

8.6.1 Unprecedented opportunities and risks

The potentials of the 'Intelligent Age' could be profound and may bring about unprecedented opportunities for humanity – or risks.

Self replicating and self-assembling technologies are being considered increasingly feasible as rudimentary proofs of concepts have been demonstrated (e.g. self-assembling microchips[46], nanostructures[47], lenses[48] and by fusing bio with nanotechnology[49]). This also raises questions about the control of such useful but also potentially dangerous technologies.

Basic research and early trials in gene therapy and extended biomedical engineering are already being conducted and rudimentary forms of Artificial Life have already being created by the Craig Venter Institute in 2010[50]. Other technologies will enable the (re-)

45 http://ieet.org/index.php/tpwiki/Singularity/
46 http://web.mit.edu/newsoffice/2010/self-assembly-0316.html
47 http://www.physorg.com/news194185863.html
48 http://www.technologyreview.com/computing/23040/
49 http://www.bnl.gov/bnlweb/pubaf/pr/PR_display.asp?prID=07-87
50 http://www.jcvi.org/cms/press/press-releases/full-text/article/first-self-replicating-synthetic-bacterial-cell-constructed-by-j-craig-venter-institute-researcher/

engineering of foods, biological structures, materials and maybe even the mind and the body. Human-animal hybrids have already been created and the bio-artist[51] Eduardo Kac has created a genetically modified Petunia that contains some of his own DNA[52]. This also opens the way to designing new life forms and genetically as well as technically modifying animals and human beings.

On the longer term, many scientists (e.g. the much debated computer scientist and inventor Ray Kurzweil[53]) believe that enabling technologies such as advanced nanotechnology and cybernetics will initiate something alike a 'post human era'[54]. Such (r) evolutionary developments are accompanied by ethical controversies concerning the future of humanity. In this sense, some may see the risk not in the failure of new technologies but in their success.

8.6.2 Ethical, legal and societal resistance

The 'Intelligent Age' is a very technology-driven trend which projects what may be possible from the perspective achievements in science, technology and engineering. This view, however discounts the fact that technological developments are and can be influenced by societal decisions. Although laws and regulations may not eliminate knowledge, curiosity and the urge to try things out, they may however make developments more difficult, costly or even illegal.

Many people have already chosen not to buy genetically modified food although its creation is technologically possible. If human cloning, for example, would be defined as a desirable goal, much progress might be made in this area, but human reproductive cloning is currently banned in most countries, a ban also backed by the United Nations on basis of human dignity.

Most of the emerging technologies described in the 'Intelligent Age' like Human Enhancement Technologies, pre-implantation diagnostics, the creation of biological chimera, certain types of neuro- and nano- and 'cyborg' technologies and synthetic biology are currently encountering heavy ethical, legal and societal concerns.

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51 A term coined by artist Natasha Vita-More (http://www.natasha.cc/)

52 http://www.transhumanism.gr/new/?cat=20

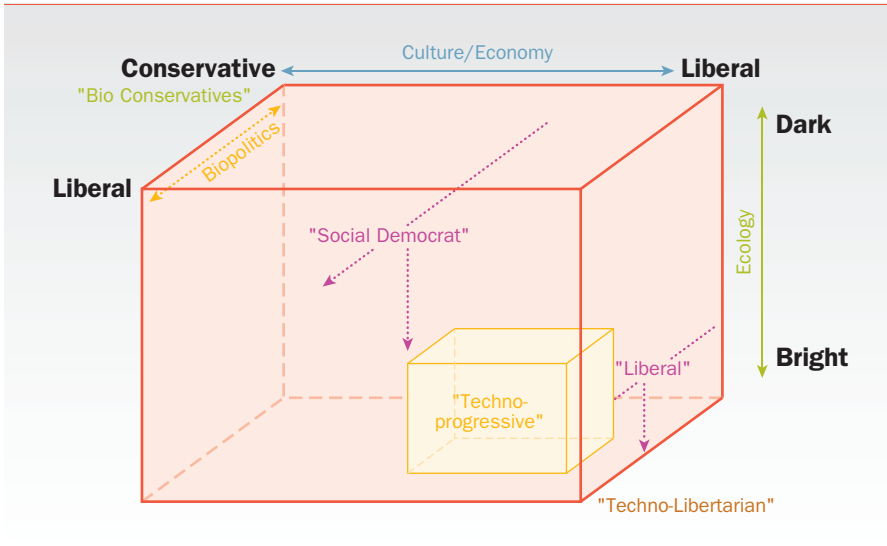
53 http://en.wikipedia.org/wiki/Ray_Kurzweil and Kurzweil, Raymond (2005) "The Singularity is Near: When Humans Transcend Biology"

54 A 'posthuman' is a hypothetical future being "whose basic capacities so radically exceed those of present humans as to be no longer unambiguously human by our current standards". However the definition may have to be looked at in a relative way, since a current human being from a post-industrialised country also possesses technologically-induced capacities that radically exceed those of humans from the middle-ages. (cf. Coenen, 2010 http://www.itas.fzk.de/deu/lit/epp/2007/coen07-pre01.pdf)

Although the regulations in regard to human embryonic stem cell research have become less strict over the last years, their regulation is still strict in many European countries[55]. The development of nootropics and technological anti-aging strategies is also legally challenging since ageing and normal human capabilities which some people may wish to enhance are not defined as disease. Thus no medication targeting ageing processes as such or healthy human capabilities can officially or legally be developed and approved in most countries.

Many concerns over technologies of the 'Intelligent Age' are related to ethical considerations and associated with fears over tampering with human nature, be it be in regard to biology, cognition or identity. Other concerns regard accessibility to potentially high-impact technologies (e.g. life or intelligence extension) as well as real physical risks (e.g. side effects and controllability).
There are also people who do not want to make use of the new potential possibilities like life extension, plastic surgery, brain-computer interfacing, neurotechnologies and human enhancement technologies. Thus, the gap between technological possibilities, legality, desirability and acceptance may increase and could even lead to a new dimension on the political spectrum demarcating advocates and opponents of the 'Intelligent Age'.

FIGURE 38: Possible New Biopolitical Landscape



SOURCE: Leis, 2008; based on James Hughes, 2004

55 http://www.mbbnet.umn.edu/scmap.html

9. Conclusion

9.1 Wrap up of this megatrend analysis

Although six megatrends may not seem much, they have been chosen to reflect most issues, trends, developments and changes to be expected in society and technology over the next 15 years at least. Penn (2007) states that "There is no single direction in which society is heading nowadays as before that could be called a megatrend. Society develops in thousands different (often opposite) small directions simultaneous". This may seem contradictory, but is in line with our approach. As our 'nesting analysis' (i.e. identifying sub-classes of topics for integration) has shown, many singular topics actually fall within one of these megatrends or are issues that are positioned lateral to many different issues and trends.

One example is health, which can be a topic of the 'Ageing Society', the 'Intelligent Age' (advanced medical technologies and human enhancement technologies), 'Fading Borders' (e.g. medical tourism) or the 'Networked Society' (e-health, telemedicine). This example shows that the pragmatically-oriented approach towards megatrends as presented in this report can provide a flexible basis for analysing specific questions (e.g. the future of the health system) within the frameset of broad, multi-dimensional socio-technical tendencies. The identification of technological and social megatrends, as it has been described in the beginning, hopefully provides a useful framework that shows that future developments are neither determined by technology alone nor by societal interests alone. One has to look at the technological possibilities and the societal factors influencing its take-up at the same time.

Thus the megatrend report may hopefully also be useful as a framework for scenario developments by providing a basis that represents issues that need to be taken into account and may require rather drastic measures to stop or alter significantly. All megatrends represent current developments that are difficult to stop or reverse in regard to their trajectories at least within the next 15 to 20 years. And even if tendencies towards reversal occur, the megatrends are very unlikely to come to an abrupt end but rather fade out slowly. Even if certain elements, technologies or world views associated with the megatrend may come to en end, the general trend is likely to continue in a recognisable way.

Some megatrends like the aging of society cannot be stopped, at least not in a way that is justifiable within current ethical, legal and societal frameworks. And even if fertility rates in Europe would sharply increase right away, the effects would take a rather long time to show. On the short to mid-term such developments could even put additional stress on finances (more need for educational institutions, medical care

for children, financing of child-care or a loss of work force and income). The same applies for a possible counter trend in decreasing life expectancy due to civilisation illnesses like obesity, which would additionally increase health costs and decrease labour productivity.

Other trends like 'Fading Borders', the 'Network Society' and the 'Intelligent Age' may even cause controversies and some demands for decreasing their development, but such societal measures would also need some time to be out in place and may result in counter-reactions themselves. It would be difficult – although not impossible – to close all borders, ban all external trade, imports and exports, shut down the internet and make research in certain areas such as genetic technologies, nanotechnology, Artificial Intelligence, neurotechnology, ageing-research and biomedical engineering illegal. It would also be extremely difficult (and ethically questionable) to destroy all knowledge that has been generated so far. Thus knowledge that has been produced is likely to remain there at least as a potential. Even if all of humanity would decide not to build any bombs it would be difficult to eliminate all knowledge that could potentially lead to building a bomb.

Especially the megatrends of the 'Risks and Security' and 'Sustainability' are currently of such great importance and also have a positive impact on innovation that it would be very unlikely that these ideas will be completely abandoned within the foreseeable future, although the dealing with these issues and the favoured options may change. These two megatrends also represent important selection mechanisms for technological development, thus making it more likely that the more sustainable, energy-efficient and safer solution will be selected than less good alternatives. This can be seen, for example, in the development of "Green IT", improved safety mechanisms in cars and other machines or in favouring external brain-computer interfaces that bear fewer risks than implanted one, although they come with less good resolutions.

This also reflects their 'interwovenness'. As long as the network society continues, borders will remain permeable. Technologies and research of the 'Intelligent Age' are also contributing to improving the quality of life within an aging society (e.g. better medication and technological support) as well as sustainability (e.g. biotechnology for energy technologies). Although technologies can bear risks, they are also necessary to reduce risks (e.g. sensor systems) and within our current stage of civilisation it would even bear a great risk to abandon advanced technologies (e.g. networking, ICT, automated systems, biotechnology, advanced medicine) or stay at the status quo without any potential for improvement and innovations for the better.

Overall, all six megatrends point at generic changes such as increasing complexity, diversity, fragmentation, interdependency and 'interwovenness'. All six megatrends are major change-forces impacting society and business and influencing individual

identity, traditional relationships among people, the notion of property, the use of knowledge and trajectories for technological developments. The megatrends have already brought about noticeable changes and innovations such as mass customisation, user involvement and user-generated content, open source, surveillance technologies, data mining and automated pattern recognition software, web 2.0 applications, large-scale renewable energy technologies, energy-efficient super computer, health care and military robots, eHealth, advanced prosthetics, neurotechnological applications, anti-aging research, nootropics and much more and even more possibly to come.

9.2 Relevance for policy makers

The megatrend concept as introduced in this report provides a theoretical framework that shows the interrelation, chances and possible conflicts between technological possibilities (e.g. networking technology, intelligent artefacts), pressing problems (e.g. concerns over risks and environmental problems) and societal issues (e.g. demographic changes and fading borders).

It could even be used as a crude algorithm which helps with the evaluation of innovation possibilities or trajectories of likely developments by taking into account the following aspects that have been identified in our analysis:

1. Technology will become more intelligent, ubiquitous and convergent and could be increasingly integrated into our environment.
2. Networks and internet-based information sharing represent the most important mode of communication.
3. The maintenance and implementation of borders will become increasingly difficult and borders are regarded as artificial constructs which leaves much room for challenging their existence.
4. More and more people have the opportunity and the will to make individual choices about their lives.
5. The life-expectancy will increase in most countries and in many post-industrialised countries birth-rates will decline.
6. Environmental sustainability will be an established factor for defining actions as positive or negative.
7. Society becomes more sensible about risks and security, calls for increasingly higher safety-standards and becomes concerned about ethical risks.

The following questions can be regarded as very important within the next decade and beyond and should be taken into account when evaluating innovative ideas:

- Is the application regarded as safe? (As described in the megatrend, it is not sufficient to provide scientific evidence about the safety status, because people have to accept the safety evaluation.)
- Is the application considered ecologically sustainable?
- Are there possibilities to make the application even more intelligent and communicative (in a safe and sustainable way)?
- How will the application be accessible or how can it be protected from undesired distribution?
- Will it be acceptable in the context of the demographic settings (in regard to age, cultural plurality, freedom of choice)?

In the Innovation Outlook Programme we have used our developed megatrend and Socio-Technical Networks concepts to identify key technologies and innovation themes with high potential and to assess their impact on specific Socio-Technical Networks.

References

References Introduction on Megatrends

- Bakas, A. (2005, 2006) "Megatrends Nederland" and "Megatrends Europe"
- Naisbitt, J. (1982) "Megatrends. Ten New Directions Transforming Our Lives", Warner Books
- Naisbitt, J.; Aburdene, P. (1990) "Megatrends 2000. Ten New Directions for the 1990's", Warner Books
- HLEG (2004) "Foresighting the New Technology Wave. Converging Technologies – Shaping the Future of European Societies", available online at: http://ec.europa.eu/research/conferences/2004/ntw/pdf/final_report_en.pdf
- Paper "Innovation Outlook – defining STN", TNO internal working paper

References Megatrend 1: Ageing and Fragmentation

- Balducci, L. (2004) "Epidemiology of Anemia in the Elderly: Information on Diagnostic Evaluation", in: Journal of the American Geriatrics Society, Volume 51 Issue 3, Pages 2 – 9
- Jain, A. K., H. Keupp / R. H.; Kraus, W. (2002) "Facing another modernity: individualization and post-traditional ligatures", in: European Review, Volume 10, pages 131-157
- Rennen, W. / Pim, M. (2003) "The Globalisation Timeline" in: Integrated Assessment Vol. 4, No. 3, 2003, pages 137–144
- UN (2006) World Population Prospects, available online at: http://esa.un.org/unpp/index.asp?panel=2

For further Reading:

- Beck, U. / Beck-Gernsheim E. (2002) "Individualization: Institutionalized Individualism and Its Social and Political Consequences"
- Casey, B. (2003) "Policies for an Ageing Society: Recent Measures and Areas for Further Reform", OECD Economics Department Working Papers , number 369
- CPB (2000) "Ageing in the Netherlands", available online at: http://www.cpb.nl/eng/pub/cpbreeksen/bijzonder/25/bijz25.pdf
- Galasso, V. and Profeta P. (2004) "Lessons for an ageing society: the political sustainability of social security systems" , in: Economic Policy, Volume 19 Issue 38, Pages 63 - 115
- Knijn, T. (2004) "Challenges and Risks of Individualisation in The Netherlands", Cambridge Univ Press
- Schulz, E. (2004) "The impact of ageing on hospital care and long-term care—the example of Germany" , in: Health Policy , Volume 67 , Issue 1 , Pages 57 – 74
- van Eijck. K. and Bargeman, B. (2004) "The changing impact of social background on lifestyle: "culturalization" instead of individualization?", in: Poetics, Volume 32, Issue 6, December 2004, Pages 447-469
- Walker, A. (2005) "Towards a Political Economy of Old Age", in: Ageing and Society, Volume 2, Number 4, p. 281

References Megatrend 2: Fading Borders

- Economist Bureau ABN AMRO (2008) "De eeuw van onze kinderen", januari 2008
- EU expert group (2005) "Reconciliation of work and private life, A comparative review of thirty European countries", September 2005
- EUMap (2008) "Across Fading Borders: The Challenges of East-West Migration in the EU", 14 April 2008, available online at: http://www.eumap.org
- Ericsson AB (2005) "Evolution towards converged services and networks", available online at: http://www.ericsson.com/technology/whitepapers/convergence_b.pdf
- Friedman, T. L. (1999) "The Lexus and the Olive Tree"
- Friedman, T. L. (2005) "The World is flat"
- Hillen, M. (2005) "De BRIC's gekraakt", Stichting Maatschappij en onderneming (SMO)
- Huntington, S. (1996) "The Clash of Civilizations and the Remaking of World Order"
- Organisation for Economic Co-operation and Development (OECD), http://www.oecd.org
- Montfort, C.J. van (2008) "Besturen van het onbekende, goed bestuur bij publiek-private arrangementen", inauguration speach at Tilburg University at 14 March 2008
- World Economic Forum (WEF), http://www.weforum.org/

For further reading:

- Mahbubani, K. (2008) "The New Asian Hemisphere: The Irresistible Shift of Global Power to the East" / ("De eeuw van Azië, de onafwendbare mondiale machtsverschuiving"), PublicAffairs
- http://www.vpro.nl/programma/globaliseringslezing/

References Megatrend 3: Environmental Sustainability

- Allensbach (2008) "Wie sehr interessieren Sie sich für Natur- und Umweltschutz?", study about Nature and Environment, available online at:http://de.statista.org/statistik/diagramm/studie/11924/umfrage/interesse-an-natur-und-umweltschutz/
- Braungart, M. and McDonough, W. (2002) "Cradle to Cradle, Remaking the Way We Make Things"; also see http://www.mbdc.com/c2c_nir.htm
- Dargay, J. ; Gately, D. and Sommer, M. (2007) "Vehicle Ownership and Income Growth, Worldwide: 1960-2030", available online at: http://www.econ.nyu.edu/dept/courses/gately/DGS_Vehicle%200wnership_2007.pdf
- European Commission (2009) "European Forum on Eco-Innovation"; see: http://ec.europa.eu/environment/ecoinnovation2008/1st_forum/index_en.htm
- Eurostat (2008) "Environmental and energy statistics", available online at: http://epp.eurostat.ec.europa.eu/portal/page?_pageid=0,1136239,0_45571450&dad=portal&_schema=PORTAL
- Footprint Network (2006) "Ecological Footprint Overview", available online at: http://www.footprintnetwork.org/gfn_sub.php?content=footprint_overview
- Glenn, Jerome C. and Gordon, Theodore J. (2007) "The Millennium Project - State of the Future 2007", World Federation of United Nations Associations, Washington D.C.
- IEA (2006) "World Energy Outlook 2006"

- LOHAS Online, http://www.lohas.com/about.html
- Meadows, D. H.; Meadow, D. L. s,; Randers, J. Behrens III, W. W. (1972) The Limits to Growth. New York: Universe Books
- Meadows, D. H.; Randers, J.; Meadows, D. L.; Tapley, E. (2004). Limits to Growth The 30-Year Update. Chelsea Green.
- Sustainability Index Online, http://www.sustainability-index.com/
- The Masdar City Initiative, http://www.masdaruae.com/
- United Nations: Report of the World Commission on Environment and Development. (1987), available online at: http://www.un.org/documents/ga/res/42/ares42-187.htm
- United Nations (2006) "World Population Prospects", http://esa.un.org/unpp/index.asp?panel=2
- Yale Center for Environmental Law and Policy / Yale University (2008) "Environmental Performance Index", available online at: http://sedac.ciesin.columbia.edu/es/epi/papers/2008EPIPolicymakerSummary.pdf

References Megatrend 4: Risks and Security

- BCC Research (2006): "Internet Security". Report ID:SAS012A, January 2006
- BCC Research (2007): "Surveillance and Monitoring of Explosive, Chemical, Biological and Nuclear Hazards", Report ID: SAS005B, August 2007
- BCC Research (2008) "Emergency Response Technologies: Global Markets" Report ID:SAS014A, April 2008
- Beck, Ul. (1986) "Risikogesellschaft. Auf dem Weg in eine andere Moderne", Suhrkamp, Frankfurt a.M.
- Businessweek Online (2008) "Germany's Nuclear Debate", available online at: http://www.businessweek.com/globalbiz/content/aug2008/gb2008087_361627htm?chan=globalbiz_europe+index+page_top+stories
- Coenen, Chr. (2008) "Summary of TAB Background Paper No. 16: Converging Technologies and Sciences 2008, available online at: http://www.tab.fzk.de/en/projekt/zusammenfassung/hp16.htm
- ETC Group (2008) "Organic Pioneer says No to Nano, ETC Group Welcomes World's First 'Nano-free' Standard", available online at: http://www.etcgroup.org/upload/publication/pdf_file/669
- EurActiv (2008) "G8: Oil, food prices endanger global economy", available online at: http://www.euractiv.com/en/energy/g8-oil-food-prices-endanger-global-economy/article-173355
- Eurobarometer (2005) Summary, see: http://ec.europa.eu/public_opinion/archives/ebs/ebs_244b_sum_de.pdf
- Eurobarometer (2005) "Europeans and Biotechnology in 2005: Patterns and Trends", report number 64.3, available online at: http://ec.europa.eu/research/press/2006/pdf/pr1906_eb_64_3_final_report-may2006_en.pdf
- Eurobarometer (2007) "Summary", Report number 67, available online at: http://www.cap-lmu.de/publikationen/2007/eurobarometer.php

- Furedi, F. (1997) "The Culture of Fear; Risk Taking And The Morality Of Low Expectations", Cassell : London
- Giddens, A. (1990) "The Consequences of Modernity" Cambridge
- ITAS (Ed.) (2007) ITAS Newsletter: Thematic focus is "Human Enhancement on the agenda?", available online at: http://www.itas.fzk.de/eng/news/2008/17.htm
- Mbbnet (2007) "Global Stem Cell Map", available online at: http://www.mbbnet.umn.edu/scmap.html
- SIPRI (Stockholm International Peace Research Institute) (2008) "Facts on International Relations and Security Trends database", available online at: http://www.sipri.org/contents/webmaster/databases
- US Census Bureau (2008) "Prohibited Items Intercepted at U.S. Airport Screening Checkpoints: 2002 to 2006", available online at: http://www.census.gov/compendia/statab/cats/national_security_veterans_affairs/homeland_security.htm

References Megatrend 5: The Network Society

- Bell, D. (1974) "The Coming of Post-Industrial Society: A Venture in Social Forecasting". London: Heinemann.
- Benkler, Y. (2006) "The wealth of networks How Social Production Transforms Markets and Freedom". Yale University Press
- Castells, M. (2000) "The rise of the network society. The Information Age: Economy, society and culture. Volume 1". Blackwell Publishing
- Chesbrough, H. (2006) "Open innovation: The new imperative for creating and profiting from technology". Harvard Business School Press
- Drucker, P. (1969) "The Age of Discontinuity; Guidelines to Our changing Society", New York: Harper and Row.
- European Commission (2009) Europe's Digital Competitiveness Report. Volume 1: i2010 – Annual Information Society Report 2009. Benchmarking i2010: Trends and main achievements. COM(2009)390
- Eurostat (2008) Community Survey on ICT Usage by Households and by Individuals.
- Perez, C. (2002) "Financial revolutions and financial capital. The dynamics of bubbles and golden ages", Edwar Elgar Publishing
- Pascu, C. (2008) "An empirical analysis of the creation, use and adoption of social computing applications", IPTS Exploratory research on the socio-economic impact of social computing. JRC-IPTS, Seville.
- Rifkin, J. (2000) "the Age of Access", New York, in: Tarcher; Putnam D. Rooney; G. Hearn and A. Ninan (2005) "Handbook on the Knowledge Economy", Cheltenham: Edward Elgar.
- Valkenburg, P.M; A.P. Schouten and J. Peter (2005) "Jongeren en hun identiteitsexperimenten op internet" (Young people and their identity experiments online) in de Haan, J. and Hof, C van 't (Eds.), (2007) Jaarboek ICT en samenleving: de digital generatie. SCP.
- Von Hippel, E. (2005) "Democratizing innovation" Oxford: Oxford University Press.
- Von Hippel, E. (1988) "Sources of innovation" Oxford: Oxford University Press

References Megatrend 6: The Intelligent Age

– "Foresighting the new technology wave", High level expert group, July 2004
– Rathenau (2008) "Het Glazen Lichaam, gegrepen door informatie"
– Gerschenfeld (2000) "When Things Start to Think". Holt Paperbacks.
– European Commission (2001) "Scenarios for ambient intelligence in 2010.", by: K. Ducatel, M. Bogdanowicz, F. Scapolo, J. Leijten & J-C. Burgelman. ISTAG report., available online: ftp://ftp.cordis.lu/pub/ist/docs/istagscenarios2010.pdf
– European Commission Research (2004) "Converging Technologies – Shaping the Future of European Societies",
– Roco, M. C. / Bainbridge, W. S. (eds) (2003) "Converging technologies for improving human performance: nanotechnology, biotechnology, information technology and cogntive science", U.S. National Science Foundation, available online at: www.wtec.org/ConvergingTechnologies/Report/NBIC_report.pdf
– Verlaan, B.; R. in 't Veld; H. van der Veen; V. Rij; P. Morin and H.M. van den Brink (2007) "Rapport Horizonscan 2007 Naar een toekomstgerichte beleids- en kennisagenda"

For further reading:

– Bostrom, N. and Roache, R. (20070 "Ethical Issues in Human Enhancement", available online at: http://www.nickbostrom.com/ethics/human-enhancement.pdf
– Fukuyama, F. (2002) "Our Posthuman Future", London, Profile
– Grunwald, A. (2007) "Converging Technologies for human enhancement – a new wave increasing the contingency of the conditio humana", available online at: http://www.itas.fzk.de/deu/lit/epp/2007/grun07-pre04.pdf
– Kurzweil, R. (2005) "The Singularity is Near". Viking.
– Nordmann, Alfred (2004) "Converging Technologies – Shaping the Future of European Societies", available online at: http://ec.europa.eu/research/conferences/2004/ntw/pdf/final_report_en.pdf
– Rifkin, J. (1998) "The Biotech Century", New York, Tarcher/Putnam

References Conclusion

– Bell, D. (1976) "The Coming of Post-Industrial Society", Basic Books
– Naisbitt, J. (1982) "Megatrends. Ten New Directions Transforming Our Lives", Warner Books
– Penn, Marc J and Zalesne, E. Kinney (2007) ""Microtrends, the small forces behind tomorrow's big changes", Twelve
– Toffler, A. (1984) "Future Shock", Bantam

Annex 1: Impacttables overall and per megatrend

The overall evaluated impact of the megatrends on 10 STN's

	UTILITIES	CAPITAL MARKET	LIVING ENVIRONMENT	QUALITY OF LIFE	COMMUNICATION AND INFORMATION	JURIDICAL SYSTEM	TRANSPORT	RESEARCH & EDUCATION	GOVERNMENT	DEFENCE, SAFETY & SECURITY	AVERAGE PER MEGATREND
Ageing and Fragmentation	1,0	3,5	4,0	5,0	4,0	2,0	3,0	2,0	2,0	2,0	**2,9 (6)**
Environmental Sustainability	5,0	3,0	4,0	4,0	2,0	2,0	5,0	2,0	4,0	3,0	**3,4 (4)**
Risks and Safety	4,0	2,0	4,0	5,0	4,0	2,0	4,0	3,0	4,0	5,0	**3,7 (1)**
Fading Borders	3,0	5,0	3,0	4,0	4,0	4,0	3,0	2,0	3,0	4,0	**3,5 (3)**
The Intelligent Age	3,0	3,0	4,0	5,0	5,0	4,0	3,0	4,0	3,0	5,0	**3,9 (5)**
The Network Society	3,0	4,0	1,5	5,0	5,0	3,0	3,0	4,0	3,0	4,0	**3,6 (2)**
Average per STN:	**3,0**	**3,2**	**3,3**	**4,7**	**3,8**	**2,5**	**3,5**	**2,7**	**3,0**	**3,7**	

Impacttable of megatrend 1: Ageing and Fragmentation on STN's

STS	DESCRIPTION OF IMPACT ON AGEING AND FRAGMENTATION	IMPACT (5=big, 1=negligible)
Utilities	Only limited impact	1
Capital market	Pension funding, "Islam banking"	3-4
Living environment	Accessibility of buildings and public environments for elderly;	4
Quality of Life	Health care system for elderly and different life styles	5
Communication and information	Different values and communication habits connected to different life-style habits. Also valid for government/business-to-person communication	4
Juridical system	Laws have to represent the diverse and different cultures, customs, norms & values	2
Transport	New design of cars and public transport systems for accessibility for elderly The safety of different life-style values in public transport	3
Research & Education	Ageing people that continue to go to university, diverse culture in students and researchers for more inspiration and creativity	2
Government	Representation of minorities in government jobs. De-alienation with government policy through fragmentized society	2
Defence, safety & security	Ageing army, risk to national security through fragmentized society	2

Impacttable of megatrend 2: Fading Borders on STNs

STS	DESCRIPTION OF IMPACT ON AGEING AND FRAGMENTATION	IMPACT (5=big, 1=negligible)
Utilities	Effects on oilprices, liberalization of energy markets, international treaties (e.g. CO_2 reduction)	3
Capital market	Free flow of capital, real-time economies, emerging trade	5
Living environment		3
Quality of Life	Spread of viruses (health, communication and virtual worlds)	4
Communication and information	"Global villages"	4
Juridical system		4
Transport	Intensifying exchange of people and goods; optimisation (easier, cheaper)	3
Research & Education	Speeding up knowledge flows	2
Government		3
Defence, safety & security	More emphasis on international relations and negotiations; sphere of influence of e.g. cybercrime	4

Impact table of megatrend 3: Environmental Sustainability on STNs

DOMAIN	DESCRIPTION OF IMPACT ON ENVIRONMENTAL SUSTAINABILITY	IMPACT (5=big, 1=negligible)
Utilities	Availability of scarce resources, higher prices for fossil fuels, alternative energy sources and new forms of distribution, energy storage, challenge of providing sufficient clean water, energy- and waste management, perhaps restructuring of system	5
Capital market	Capital markets will become an important institution for regulating (or influencing) the prices of scarce goods (e.g. oil), energy prices will influence economic performance	3
Living environment	More investments in energy efficiency and retrofitting, low / zero energy houses, natural materials, new value of nature/parks/greenery, changes in city and housing design (e.g. Masdar City, living on water)	4
Quality of Life	Eco-living, LOHAS and consumers' choice for sustainable products; in the bad-case scenario: decreasing quality of life, food and water shortages, conflicts, environmental refugees	4
Communication and information	Green ICT, the influence, the media will remain the main source to transport the message of sustainability efforts, weighing ICT-based work against travelling	2
Juridical system	Environmental damage as crime? More lawsuits about pollution issues, Biopatenting conflicts will represent new issues for legal institutions	2
Transport	Energy prices will rise, public transport could become more interesting, new cars/car alternatives, fuel price and sustainability concerns could impact air travel (although the impact s not felt yet), if the polar ice is melting, new routes will be accessible for ships.	5
Research & Education	Sustainability and energy efficiency as school subject? New university courses in environmental/energy technology, bionics, water and waste management and related topics. Universities will be among the drivers for innovations and solutions, necessity for interdisciplinary co-operation	2
Government	International relations and treaties in regard to environmental issues, new laws and regulations on domestic and international level, energy policy, biopolitics will emerge as a new political dimension	4
Defence, safety & security	Potential conflicts over resources and even basic needs, assignment of military for humanitarian aid	3

Impacttable of megatrend 4: Risks and Security on STNs

DOMAIN	DESCRIPTION OF IMPACT ON ENVIRONMENTAL SUSTAINABILITY	IMPACT (5=big, 1=negligible)
Utilities	Safety of energy production and transmission facilities (e.g. nuclear power plants, oil fields, terrorist attacks against energy infrastructures), safety of drinking water	4
Capital market	Dealing with financial crisis, slow down globalisation	2
Living environment	Concern about natural catastrophes, safety of housing, harmful substances, earthquake safety	4
Quality of Life	Growing concern about health risks, growing importance of live-work-balance, psychological factors, issues about medicine, ethical risks, life expectancy/ aging, financial security, social security concerns, unemployment, impact of terrorist warnings on quality of life, slow down globalisation, xenophobia	5
Communication and information	Internet and data security, personal privacy, surveillance, slow down internet/networking usage	4
Juridical system	Liability issues	2
Transport	Safety of personal transport, air safety, terrorism	4
Research & Education	Education and employment, school violence, re-evaluation about the safety of safety measures	3
Government	International relations and treaties, safety laws and regulations, committees, influence of NGOs, role of safety and risk experts for political decisions	4
Defence, safety & security	Terrorism, national security, military for internal affairs and security, dealing with new weapons (e.g. biological) and new ways of warfare (e.g. info-war), public security, surveillance	5

Impacttable of megatrend 5: Network Society on STNs

STS	DESCRIPTION OF IMPACT ON AGEING AND FRAGMENTATION	IMPACT (5=big, 1=negligible)
Utilities	Local (distributed) energy, intelligent metering	3
Capital market	Easiness to invest abroad	4
Living environment	Location based services	1 / 2
Quality of Life	Communication and contact with others, making new friends, prevents isolation (elderly, handicapped); Addiction to internet, games, withdrawal from offline life; importance of digital skills, also (prevention of) digital divide	5
Communication and information	Privacy issues, Identity management	5
Juridical system	Copyrights, Online behaviour, international regulation, Developing new laws in virtual worlds	3
Transport	Travel information systems, location based services, transport optimisation/ multi modal transport	3
Research & Education	Science: Mode II (Gibbons), new scientific discoveries (breakthroughs?) Education: life long learning, Serious Gaming	4
Government	focus on policies that foster the creation of knowledge (fostering a climate of innovation) and pursuit of learning (investing in people and skills and promoting life long learning); citizen-government information and participation, e-democracy	3
Defence, safety & security	Networked soldier, networked enabled capacities, everyone localised decision making, protecting infrastructure.	4

Impacttable of megatrend 6: The Intelligent Age on STNs

STS	DESCRIPTION OF IMPACT ON AGEING AND FRAGMENTATION	IMPACT (5=big, 1=negligible)
Utilities	Smart grids	2
Capital market	Intelligent agents for trading	3
Living environment	LBS, smart homes, robotic and AI assistance, smart objects, intelligent computers, biotechnologies, smart materials, sensor networks	4
Quality of Life	Advanced medical technologies, biotechnology, healthy aging/life extension, human enhancement technologies, improves safety and security, new and potentially unprecedented risks	5
Communication and information	Semantic web, data analysis, intelligent computers and robots/advanced AI	5
Juridical system	Liability, regulating human-machine interactions and responsibilities of 'hybrid systems', biopolitics, new questions in regard to the beginning and end of life and between intelligent biological and non-biological systems, rights for robots?	4
Transport	Intelligent cars, intelligent infrastructures (sensor systems)	3
Research & Education	Faster research, acceleration of R&D and innovativeness	4
Government	New political dimensions and conflict lines (e.g. along biotechnology, genetics, human enhancement technologies and advanced AI)	3
Defence, safety & security	Biological warfare, bioterrorism, intelligent agencies, modelling and simulation, military robots, cyborg soldiers, nanotechnology for safety, security, defence and warfare	5

For a description of the STNs, see Box II

Annex 2: Examples of interrelations between the six megatrends

Mega Trends: Dependencies and Challenges

	NEW DEMOGRAPHY	FADING BORDERS	RISKS AND SECURITY	SUSTAINABILITY	NETWORK SOCIETY	INTELLIGENT AGE
NEW DEMO-GRAPHY						
FADING BORDERS	**How to enable cooperation?** collaboration and learning technologies					
RISKS AND SECURITY	**How to avoid social security problems?** improving health and working conditions	**How to avoid global threats?** technologies for improving international security				
SUSTAINABILITY	**How to create individualized and sustainable products?** small scale production; eco products	**How to improve global sustainability?** global exchange of sustainability solutions	**How to minimize environmental and scarcity problems?** environmental and energy technologies			
NETWORK SOCIETY	**How to make networking more customized?** social networking and virtual identity technologies	**How to improve global networking?** next generation smart internet	**How to enhance ICT security?** ICT security technologies, surveillance and privacy protection	**How to use network concepts for improving sustainability?** decentralization; ICT-based workers		
INTELLIGENT AGE	**How to avoid aging problems?** technologies that counter the negative effects of aging	**How to achieve global access to vital technology?** development of products like the "100$ Laptop"; adaptation of technologies to specific cultural settings	**How to avoid risks of complex technologies?** smart safety technologies	**How to use smart technology to maximize sustainability?** AI-based efficiency management; simulation technologies	**How to combine networks with intelligence?** ubiquitous computing, semantic web	

This report presents six megatrends that reflect the main issues that will greatly influence western societies. They represent current developments that are difficult to stop or reverse, at least within the next fifteen to twenty years. The six megatrends have been chosen to reflect most issues, trends, developments and changes to be expected in the future society and technology, based on a 'nesting analysis'. Many singular topics - that also could be considered microtrends - may seem different (and often opposite) small directions simultaneous, but they actually fall within one of the six megatrends. The megatrends analysis as presented in this report provides a theoretical framework that shows the interrelation, chances and possible conflicts between technological possibilities (e.g. networking technology, intelligent artefacts), pressing problems (e.g. concerns over risks and environmental problems) and societal issues (e.g. demographic changes and fading borders). It focuses on innovations within and crossing over the concept of so called 'Socio-Technical Networks' (STN), that consists of humans, technologies and modes of operation and functions as a distinct unit to provide certain goods and services for society.

"Megatrends: a broad outlook on innovation" represents one of the main features of TNO's Innovation Outlook, which aims to systematically and periodically identify and compare different trends in innovations in order to assess the potential impact of these innovations on our society. It provides insight into the innovation dynamics in the Netherlands.

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