Using foresight to support the next strategic programming period of Horizon 2020 (2016-2018)
Executive Summary

This report is based on a study of foresight into the drivers of change and disrupters affecting the future of Europe and the strategic responses that the European Commission should consider in shaping the second strategic programme (2016-2018) of Horizon 2020. Importantly, the study was designed to use available foresight material. It is therefore focused on sense-making, rather than the generation of original intelligence.

Whilst the study cannot claim to be comprehensive, it nevertheless points out that foresight used in strategic planning offers insights, generates ideas and brings to the fore important cross-cutting domains. The use of foresight can help ensure that Horizon 2020 strengthens the competitiveness of Europe and enables it to respond to the significant current and future societal challenges.

From the analysis and expert consultations carried out during the project, 12 drivers of change and six disrupters have, individually and in combination, the potential to impact significantly the future of Europe and of its citizens.

The drivers selected are: 1) Population changes, migration and ageing; 2) Globalisation; 3) Personalisation and expansion of healthcare and disease prevention; 4) Environmental change & degradation; 5) Personal aspirations and empowerment; 6) Urbanisation; 7) Education revolution and gender equality; 8) New and emerging technologies; 9) Space exploration and exploitation; 10) Changing creativity and innovation; 11) IT, connectivity and networks; 12) Scarcity of resources and energy.

Of those drivers, the most influential (i.e. 'drivers' that influence other 'drivers') are: 1) IT, connectivity and networks; 2) New and emerging technologies; 3) Population changes, migration and ageing; 4) Environmental changes and degradation.

While the reasonably well-understood and predictable path of the 'drivers of change' enables us to frame future needs for Horizon 2020 in a relatively reliable way, other influences could reverse, interrupt or disrupt identified trends and outcomes. These 'game-changers' or 'disrupters' create serious risks, but also extraordinary opportunities. The six disrupters identified in this study are: Values and beliefs; trust and reputation; tech surprise; conflict and insecurity; crisis-prone global economy; and rampant vulnerability to natural disasters.

The interactions of these 18 factors (the 12 drivers and 6 disrupters) point towards eight essential areas that need a strategic response from Horizon 2020:

- **Population changes, migration and ageing**: exploit opportunities emerging from multiculturalism, and from worldwide population changes; research and technology to support controlled migration and integration of migrants; address the resilience needs of health systems against emerging epidemics; at exploiting the opportunities created by the conjunction of health, ageing, the environment and social conditions; invest in technology domains which mitigate ageing;
support social interventions to combat isolation of older Europeans

- **Globalisation and fragmentation**: feed intelligence into R&D activities and enable innovation experimentations, particularly for Small and Medium Enterprises

- **High expectations attached to new technologies**: strengthen the embeddedness of new technologies in their social contexts; ensure expertise is available to ‘regulate out’ negative technology surprises and take corrective action as needed; consider partnership strategies for expected technological advances

- **Transversality in new technologies and individualism**: encourage the development of transversal platforms and the search for new transversal infrastructures; encourage focus on user interfaces

- **IT, connectivity and networks**: IT is becoming part of the fabric of our societies and is highly sensitive to disruptors; focus on trust, values, systemic resilience together with universal connectivity affordably; cyber-security and cyber defence are key areas

- **Vulnerabilities test our reliance**: redress the balance between climate-change mitigation and adaptation strategies to strengthen adaptation; improve forecasting models

- **Environmental changes and degradation**: encourage a behaviour change among economic actors to reduce pollution; support circular economy models

- **Responding to the scarcity of resources and energy**: support new technologies with low resource consumption; support technological alternatives for resource use; seek to develop radically new sources of energy and key materials

The drivers of change and disrupters developed in this study are annexed to this report in order to be used by the Commission in further endeavours that will refine them more and increase their usefulness for Horizon 2020.
European Commission

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Disclaimer

The information and views set out in this report are those of the author, Vincent Rousselet & Associates Ltd, and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in the report. Neither the Commission nor any person acting on the Commission’s behalf may be held responsible for the use which may be made of the information contained therein.

The author is grateful to Gill Ringland and Matthias Weber for their support and contributions to this study. The author would also like to thank the experts who took part in the study by dedicating their time in the interview and workshop attendance process. However, the responsibility for all content of this report remains with the author.

“It is far better to foresee even without certainty than not to foresee at all.”

Henri Poincaré

The Foundations of Science (1913)
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Part 1: Background

1.1 What is Horizon 2020?

Horizon 2020 is the biggest EU Research and Innovation programme ever, with €79 billion of funding available over seven years (2014 to 2020) – in addition to any investment that this money will attract. It promises more breakthroughs, discoveries and world-firsts, by taking great ideas from the research lab to the market.

Building on the successes of the Seventh Framework Programme (FP7), Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at exiting the current economic crisis and at securing Europe’s global competitiveness.

Seen as a means to drive economic growth and create jobs, Horizon 2020 is an investment in our future and so put it at the heart of the EU’s blueprint for smart, sustainable and inclusive growth and jobs.

By coupling research and innovation, Horizon 2020 is helping to achieve this with its emphasis on three domains:

- excellent science,
- industrial leadership,
- tackling societal challenges.

The goal is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together to deliver innovation and competitiveness, and to address societal challenges.

1.2 The need for foresight

Horizon 2020 is guided in its priorities and its choices by the vision and the priorities of the Europe 2020 strategy. However, within the scope of the descriptions of those priorities there is room to manoeuvre in terms of emphasis, timing and modes of implementation of the programme, in order to respond to changes in its context, including new developments in economy, society, polity as well as science and technology.

It is in defining the strategic priorities for the implementation of the programme that the need for foresight was felt, and it was this need that motivated this study, commissioned at the end of 2013.
1.3 The aim of the study

The study is a pilot - an experiment. It is not carrying out foresight. It seeks to use available foresight material to help strengthen the basis of the second strategic programme (2016-2018) of Horizon 2020.

In this sense, there is no new intelligence in the study. Rather, it represents an effort in sense-making, i.e. in trying to distil useful information and frame it in a way that is usable in the context of a particular decision-making process.

Being a pilot, the study does not pretend to provide a comprehensive review of all available foresight. It is based on a selection of relevant and recent foresight literature, either made available by the Commission services or identified from public sources by the author.

The material was synthesized, with contributions from interviews with a small number of selected foresight experts (see appendix 2), into 20 “drivers of change” and six “game-changing disrupters”. The drivers and the disrupters, and their potential implications for Horizon 2020 were discussed in a workshop with 28 external experts and a number of Commission officials with expertise spanning the different domains of Horizon 2020 (see appendix 3).

The present report is largely based on a synthesis of those discussions. Whilst the participation in the workshop was very multidisciplinary, it did not establish a complete coverage of the programme, nor a fully representative sample of opinions. This is consistent with the pilot character of the study. The aim of this report is to develop the insights that emerged from the workshop into strategic considerations and ideas that can help the definition of future priorities.

Following the workshop, it was felt that the relevant forces of future change are better grouped into 12 drivers of change. The second section provides a quick overview of those drivers and an analysis of their relevance for the different parts of Horizon 2020. More detailed descriptions of the drivers can be found in Annex 4. The third section presents the six disrupters and attempts to illustrate the opportunities and threats associated with them, and their relations with crucial drivers of change.

The final section draws strategic implications for Horizon 2020, with an emphasis on the second strategic programme period (2016-2018). Whilst the focus is on the level of the strategic programme, the aim is not to suggest specific topics or specific priority areas. Instead, the report seeks to elicit strategic considerations that help to decide the areas to address. Inevitably, the spotlight also falls onto important policy issues (migration, security, globalization etc.), where political priorities themselves would have important implications for research and technology. However, developing those is a task beyond the remit of this report.
Part 2: Foresight and the future: drivers of change

Foresight is about anticipating and thereby shaping the future. An essential step is to identify factors that stimulate change. These factors are called change drivers, representing measurable increasing or decreasing trends, issues or events, or combinations thereof that are likely to cause change. Policy decisions can then be formulated on the basis of concerns about the desirability of the prevailing direction of change.

Drivers of change are analytical constructs that bridge past and present with the future, and therefore they are likely to involve recourse to evidence from the past as well as normative elements about the future. In their descriptions, they may make reference to natural and social forces and combinations of the two. In the relationship between foresight and policy, drivers are like levers that policy could act upon in order to shape the future.

In the context of this study, the identification of drivers was carried out through a literature review and initial expert discussions. From these a preliminary list of 20 change drivers was debated at the workshop and finessed to arrive at a list of 12 drivers of change with implications for Horizon 2020.

2.1 Drivers of change

The drivers developed are characterised by four common features:

- Each delivers a fundamental and long-lasting impact on the future (for instance, a new technology like 3-D printing has the potential to transform the manufacturing sector)
- It is associated with a well-researched body of literature indicating a relatively unambiguous 'direction of travel' (such as the continued increase in urbanization in both Europe and across the world)
- Each has been at play for a decade or more (in the case of space exploration for example, over five decades have passed since the successful Sputnik launch in 1957)
- It has a wide array of ramifications on other factors (for example the impact of population ageing on changing healthcare needs and increasing costs)

Detailed descriptions of the drivers used in the study can be found in Appendix 4.
2.1.1 Population changes, migration and ageing

Total world population continues to grow to a likely peak of 9 billion by 2050, but it does so in an uneven way. Europe is facing a rapidly ageing population in the short to medium term, and a population reduction in many countries in the longer term. International migration is also increasing as incentives and the ability of people to move increase. The spread of education and affluence impact on birth-rates and longevity, which are also pushed by advances in health and medical care.

Ageing population is the cause of new economic and societal issues in Europe. A reducing active population has to bear the cost of a larger, older group. Social models of solidarity and fairness need to be reshaped. Increasing immigration and longer working lives are two of the most discussed aspects of the new social model.

By way of illustration, the graph overleaf, sourced from the WHO ([http://wisdom.unu.edu/en/ageing-societies/](http://wisdom.unu.edu/en/ageing-societies/)), gives a good snapshot of the generally accepted forecast of the world population. The ageing trend is especially marked in Europe.

Graph 1: World population by age group – 1950 to 2050

2.1.2 Globalisation

Globalisation is a process of international integration covering increasingly the planet and characterised by the growing movement of goods, capital, information, people and services around the globe, itself resulting from liberalisation of trade over the last half of the last century and the establishment of an almost global information and supply chain infrastructure.

Part of this process involves the rise of new economic powers and new distributions of economic activity.

Many data points can serve to illustrate the globalisation phenomenon, from the rise of international trade to the location of multinational companies. Graph 2 below,
sourced from BRIC Consulting (http://www.bricconsulting.com), demonstrates the projected economic growth together with the shift of the world’s economic centre of gravity, which are related to globalization.

Graph 2: G6 and BRIC GDP – 2000 to 2050

2.1.3 Personalisation and expansion of healthcare and disease prevention

Population changes and rising expectations drive increasing demands on the healthcare sector.

Fast advances in medical treatments are on the map to address these demands. The convergence of technology and medicine, aided by the intense collaboration already at play across national boundaries, will trigger innovation, such as nano-robots, remote surgery and personalised drugs & diets. Emerging opportunities do not eliminate the risk of cost explosion and social exclusion which is driven by population changes combined with environmental degradation.

Here again, a wealth of data and forecasts can represent the fundamental transformation taking place in healthcare. The graph below, from the OECD, represents the pressing financial challenge caused by the rise in healthcare costs.

Graph 3: Annual growth in GDP and Health spending in the OECD – 1970 to 2008

2.1.4 Environmental change and degradation
Environment degradation is the reduction of the capacity of the environment to meet social and ecological objectives, and needs. It involves the destruction of natural habitats and the depletion of natural resources.

Environmental change and degradation are both natural and man-made. Man-made degradation often comes through intensive use of resources and waste production. A particular concern is the change in climate which affects biodiversity, resources and human population as well as the global balance of political and economic power.

A recognised indicator of environmental change is the rising trend in observed temperatures, as expressed by the diagram overleaf, sourced from New Scientist. Forecasting models predict that an increase of more than 2°C will result in destructive climate change and in a dangerous positive feedback loop accelerating warming.

Graph 4: World Temperatures – 1880 to 2010

2.1.5 Personal aspirations and empowerment

The increasing capacity of individuals to do things and express themselves goes hand in hand with growing expectations for individual empowerment. Overall, re-defining the sense of self, which encompasses dimensions such as personal ambition, one’s preferred lifestyle and work / career trajectory, is becoming an important priority for many, especially in the younger generations (e.g. digital natives).

New attitudes rejecting ostentatious consumption are appearing in the West, perhaps more so than in other regions globally. Combined with the ability to share or lease services and products rather than owning them, a new model of consumption becomes established within a circular economy. The map below, sourced from Eupedia.com and based on Geert Hofstede’s research, represents the geographical spread of individualism and collectivism across Europe.

It highlights the varying cultural attitudes within the continent when facing the question of individual fulfilment.
2.1.6 Urbanisation

Over half of the world population now lives in cities. In Europe, it is expected that 80% of the population will be urban by 2050. Environmental and energy-efficiency considerations favour urban lifestyles, while the dependence of urban life on infrastructure, transport and logistics can challenge food availability, induce new vulnerabilities and require new answers to enhance resilience of urbanized areas.

As with all the change drivers described in this section, there is a well-researched set of forecasts for the continued urbanisation of the planet, as illustrated by this graph sourced from New Geography.

2.1.7 Education and gender equality

Education is a fundamental factor in development and societal progress, enabling literacy and facilitating the integration of individuals in society in general and in employment in particular. Combined with gender equality, education contributes greatly to the containment of population growth.
According to UNESCO, in 2010, 84% of global population was literate, a jump of more than 5% compared to 2000. The number of students around the globe enrolled in higher education is forecast to more than double to 262 million by 2025. Education is undergoing significant transformations, enabling increasingly personalized and tailored learning experiences.

2.1.8 New & emerging technologies and practices

The combination of various scientific fields is bringing new applications which are adopted widely across society and hold promise for radical improvements in a wide array of domains, such as manufacturing, health, agriculture and service industries. Technological convergence expands vastly the terrain of potential technological innovation, towards new directions at the nano-scale (e.g. programmable materials) and towards very large scale (e.g. go-engineering).

An important direction of change in the context of technological convergence which is facilitated by IT, concerns the increasing ability to deliver transversal service platforms, combining infrastructures and technology and cutting across established sectorial boundaries, to deliver increasingly individualized services to users. This transversality provides opportunity for reshaping infrastructures, services and user-interfaces, and for rethinking and restructuring global supply chains in all kinds of services.

The forecast, by Gartner, of 3-D printer sales is given here as an illustration of the pent-up demand which such innovations can unleash.
2.1.9 Space exploration and exploitation

Space is already used today in a range of applications, such as communication and environmental & military observations. While space technology makes significant contributions to the improvement of the performance of technologies and services on earth, only a small fraction of the possibilities offered by space is exploited or even known.

Pushed by diminishing resources and energy sources on the planet, we are seeking to explore and exploit the theoretically infinite reserves of space. The illustration overleaf, sourced from Strategy Analytics, is just one proof point of this growing trend.

2.1.10 Changing creativity and innovation

The increase of open innovation agreements between multiple actors challenges traditional model of IP ownership. Access to knowledge, the growing role of entrepreneurship culture, changes in personal identity and identification with community interests and values all contribute to a fundamental shift in creativity. The growth in inventions being generated, at least partially, by machines and computers opens new possibilities.
In science, shifts in the processes of generation of new knowledge are included in the phenomenon termed “Science 2.0” (including phenomena such as “big data” and citizen science). The acceleration of knowledge-production through the ability of technology to generate technology (or at least the ability of technology to accelerate the rate of production of technology), fuels techno-optimism, i.e. the belief that new discoveries and innovations will happen to deal with problems that are unsolvable with the current state of knowledge.

The illustration chosen for this change driver echoes the eastern shift indicated earlier under the globalisation driver. The growth in patents in China and Korea, demonstrated by this diagram sourced from the WIPO Statistics Database, is remarkable.

2.1.11 IT, connectivity and networks

With abundant bandwidth and devices, commerce, trading as well as social and business interactions become increasingly virtual, potentially negating the need to commute, travel or meet real people. As people and machines connect through mobile devices and implanted chips, an avalanche of data is gathered, stored and analysed. This increases the risk of security and privacy breaches whilst holding the promise a safer, simpler world for individuals.

Perhaps the most striking illustration of the pervasiveness of IT is the growth in data, as showed below in a graph sourced from Philippe Botteri, a specialised IT venture capitalist.
2.1.12 Scarcity of resources and energy

The collision of population growth, the rise of a global “middle class”, and climate change creates overwhelming pressure on food, water, materials and energy reserves. A number of developed economies are at risk of experiencing power blackouts as energy demands exceed temporarily supply outputs. Some observers estimate that two planets will be needed to sustain the Earth’s population in 2050.

The prediction in global energy demand, by the US Energy Information Agency, and showed on the next page demonstrates once again the rise of new economic powers in the East.

Graph 11: Growth in structured and unstructured data

Graph 12: Global energy consumption – 1990 to 2020
2.2 How drivers of change inter-relate

Our expert discussions throughout the study have highlighted the importance of understanding the inter-relations between each of the trends at play, as convergence of two or more factors may present new challenges, as well as new opportunities, for Europe and the world.

The development of new food technologies for example, can address the growing scarcity of nutrients, against a backdrop of global population expansion. It can be coupled with ICT capabilities and satellite observations, to create big data forecasts of weather patterns for improved crop yield, and with an integrated supply chain constantly enhanced by the continued globalization of the economy. Hence new food technologies make more likely our ability to feed 9 billion people on the planet by 2050, whilst providing export opportunities for European farmers.

The table overleaf aims to represent the impact of each of the 12 change drivers (in the first column on the left) on the remaining 11 (across the top). Three levels of impact are represented.
**European Commission**

**Using foresight to support the next strategic programming period of Horizon 2020 (2016-2018)**

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**Table 1: Inter-relations between change drivers**

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**Key**

- **Strong impact**
- **Moderate impact**
- **Low to no impact**

**Source:** Vincent Rousselet & Associates
On average, each change driver impacts strongly four other drivers, and also has some influence over another three and a half drivers. The most influential drivers within this analysis are:

- Population changes, migration and ageing: the pervasiveness of the demographic trends in action across the world means much of our daily life for decades to come is affected.
- Environmental changes and degradation: this is another very powerful trend which affects multiple drivers – including the well-being of individuals.
- New and emerging technologies: this driver holds the promise of a more intelligent future able to tackle the social, political and economic challenges faced by our world.
- IT, connectivity and networks: this factor enables many of the changes taking place around our society and our economy.

A more visual representation of the connections between drivers is given below in a simplified mind-map, describing only the higher-order impacts plotted in Table 1. Where two drivers influence each other, this is represented by a double-arrow in green.

Diagram 1: Mind-map of the 12 drivers of change
2.3 How drivers of change relate to the content of Horizon 2020

Assumptions and expectations about the change drivers identified during our study have already been incorporated into Horizon 2020, especially in the parts for Emerging Industrial Technologies and Societal Challenges.

Horizon 2020 seeks to address seven societal challenges.

Table 2: The seven societal challenges of Horizon 2020

| 1. Health, Demographic Change and Wellbeing |
| 2. Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy |
| 3. Secure, Clean and Efficient Energy |
| 4. Smart, Green and Integrated Transport |
| 5. Climate Action, Environment, Resource Efficiency and Raw Materials |
| 6. Europe in a changing world - Inclusive, innovative and reflective societies |
| 7. Secure societies – Protecting freedom and security of Europe and its citizens |

The relevance of the 12 drivers for the societal challenges is depicted in Table 3 overleaf.
Table 3: Relation between H2020 Societal Challenges and Change Drivers

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Source: Vincent Rousselet & Associates
In addition Horizon 2020 seeks to ensure Europe’s industrial leadership globally in emerging industrial technologies.

Table 4: The six Emerging Industrial Technologies

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<td>1</td>
<td>Biotechnology</td>
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<td>2</td>
<td>Information and Communication Technologies, including five sub-components:</td>
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<td>a. New generation of components and systems</td>
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<td>b. Advanced Computing</td>
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<td>c. Future Internet</td>
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<td>d. Content technologies and information management</td>
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<td>e. Robotics</td>
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<td>3</td>
<td>Nanotechnology, including Nano/Microelectronics and Photonics</td>
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<td>4</td>
<td>Space</td>
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<td>5</td>
<td>Advanced materials</td>
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<td>6</td>
<td>Advanced manufacturing and processing</td>
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The Leadership in Enabling and Industrial Technologies (LEIT) part of Horizon 2020 supports the development of technologies underpinning innovation across a range of sectors, hence connecting with the changing creative and innovation driver identified in this study. Horizon 2020 is designed to have a strong focus on developing European industrial capabilities in Key Enabling Technologies (KETs).

Three of the drivers of change developed correspond closely to the LEIT part of the programme: new & emerging technologies, space exploration & exploitation and IT, connectivity and networks. As can be seen in Table 3 these drivers are also highly relevant to a number of societal challenges.

This picture emerges for most drivers of change, which have strong relevance to one or two parts of Horizon 2020 but also implications for other parts.

For example, population changes, migration and ageing are represented primarily in demographic change (challenge 1), while they also have important implications for food security (2), transport (4), Europe in a changing world (6) and secure societies (7), in the context of Horizon 2020.

As drivers cut across challenges of Horizon 2020, they form important cross-thematic targets for EU policy. However, our drivers are defined at a high level of analysis. An important consideration is therefore what is the appropriate level of analysis for cross-thematic targets in the context of the strategic programme of Horizon 2020.

The workshop that was part of this study did not reflect on this question. For our analysis two considerations for drawing strategic conclusions were:

- The importance of the drivers concerned; and
- The potential role of disrupters.
Part 3: Important future disrupters

Part 2 of this report described the set of 12 change drivers which, individually and collectively, have a fairly well understood pathway. It is nevertheless the case that, in addition to these drivers, there are other influences that incorporate important contradictions and may have dramatic effects on the future.

These game-changers are reckoned by many experts to shape new opportunity and innovation spaces, and entirely new kinds of challenges, radically different to what there is today. They are therefore important factors that the orientations of Horizon 2020 must bear in mind. For example, when thinking about future scenarios involving the disrupters, it may be more appropriate to focus on the degree of preparedness of society for disruption, rather than on their desirability.

From our workshop and expert interviews, six important disrupters have been identified. They are:

- Values and beliefs
- Trust and reputation
- Tech surprise
- Conflict and insecurity
- Crisis-prone global economy
- Rampant vulnerability to natural disasters

These factors share five characteristics that make them stand apart fundamentally from the 12 drivers of change examined earlier:

- They are understood to be very important factors for the future in fundamental ways.
- There is a limited amount of research pointing at trends in them as disrupters, and what little there is tends to emerge from ‘weak signals’ or ‘wild cards’ considerations.
- There is, at best, only a short history of observable precursors; in some cases, the putative factor is entirely conjectural and future-based.
- The range of potential outcomes is much wider and can be highly polarised between extremes, from positive to catastrophic.
- Game-changers can be implicated in sudden events or tipping points (such as the collapse of the euro or of the European Union triggering a major economic and social crisis).

Appendix 5 gives a detailed description of the six disrupters which Horizon 2020 needs to take into account, including references to relevant ‘weak signals’ perceptible today.

This section gives an overview of each individual disrupter and discusses in short its potential impact on the drivers of change reviewed in Part 2 above.

3.1 Values and beliefs

Values drive the personal conduct of individuals and, in aggregate, that of economic actors. A polarisation in values would trigger contradictory behaviours and create tensions (some visible today in the debate across Europe on immigration, both coming
from outside and inside the continent). On the other hand, the natural evolution of values and beliefs enables the development of new value systems in an on-going dynamic process.

Using a variety of sources, including the World Economic Forum Risk Report and the iKnow community library, it is possible to structure an example of a disruptive cascade originating in a shift in values and beliefs impacting five change drivers with serious consequences.

In such a scenario, rising religious fanaticism could trigger a backlash against globalisation. Coupled with a massive incident of data fraud and a number of cyber-attacks, facilitated by IT connectivity, the situation could prompt a wave of digital misinformation which washes over the world. This, in turn, could fuel a large-scale coordinated terrorist campaign as well as a failure of the financial and energy supply systems in many countries. Longer term, this could cause new population migrations and could spur the development of new religion-oriented education streams.

3.2 Trust and reputation

Trust can be defined as the belief that people will behave predictably. Institutions are built on trust and are a means to develop trust. The more interdependent people, economic actors, and institutions are becoming the more important trust is for the effective functioning of our societies. Trust is correlated with fairness and responsiveness to societal concerns.

An increased willingness to trust electronic communications (with human or computer interlocutor) has resulted in significantly increased commerce, financial activities, institutional efficiency, information exchange, and social interaction.

In contrast, a generalised breakdown in trust could have disastrous consequences. Such a breakdown could be triggered by an acute case of corruption within an institution in Europe, such as a national or supra-national governmental body. From an apparently contained incident, a crisis of confidence with the whole governance system could develop. Apart from social unrest, such a mistrust of the political governance of our society would almost immediately generate a high degree of uncertainty and impact much of commerce and the financial system. This could even undermine the basis of human interactions in society and its democratic underpinnings. Even if public order could be maintained, widespread disruptions to supply chain and public services would follow and make everyday life unbearable.

3.3 Tech surprise

Major technological leaps such as the advent of antibiotics, genetic engineering, the transistor, nuclear power, catalysts, photo-voltaics and the Internet have had an immense impact on society and economy. Technological leaps with positive effects are expected in many fields.
The convergence of different technologies and the rising investment in R&D is generating an environment of techno-optimism, driven by a strong belief that technological breakthroughs are out there to be achieved and all we have to do is develop them through brain-power and R&D investment. However, technology can also have unintended negative consequences. When combined, the level of complexity of much of technology research and the hard-to-identify ramifications of a given domain connecting to others present large-scale risks.

For example, the manipulation of matter on an atomic and molecular level could raise toxicity problems, with a knock-on effect on the progress of individualised health treatments.

Much in the same way, advances in genetics and synthetic biology may engender unintended consequences, such as the emergence of new species or weapons.

This in turn could slow down desirable trends such as the eradication of diseases or the elimination of hunger.

3.4 Conflict and insecurity

Wars and conflicts appeared to be reducing after the end of the cold war, but this trend seems to have stopped. Wars and conflicts may well remain a constant in the coming decades, with likely more civil wars and terrorist activities and certainly a rise in cyber-crime and cyber-war. Some see the emergence of unconventional weapons (such as deadly viruses) as a possible escalation in new conflicts, driven by state or non-state actors. As an example, the civil war in Syria has already the dubious hallmarks of being a training ground for the deployment of unconventional weapons. It is also a war by proxy between regional powers and has triggered a significant movement of populations into neighbouring countries and indeed Europe.

Even without contemplating an all-out war situation – be it in the Middle East, East Asia (Korea) or Africa - this disrupter could intervene in Europe. A trigger might be a social conflict originally limited to a city or a region (such as the inner city riots in England in August 2011) morphing into a national or international issue. Increasing poverty in Europe, fed by on-going economic recession and austerity policies could result in food crisis, survival struggle and social unrest with increasing hostility towards the European integration project.

Together with a regain of populism and a return to national, rather than European, responses, this could ultimately lead to the dissolution of the European Union. A weakened unifying and moderating framework raises the risk of the emergence of new divisions and conflicts within Europe.
3.5 Crisis-prone global economy

The 2008 crisis has weakened both state and private financial actors as well as damaged the financial well being of the majority of the population in much of the western world. Given the anaemic recovery experienced in the last two years, successive economic shocks may create a downward spiral of economic depression, protectionism, social unrest and political extremism.

Starting with unmanageable inflation (or deflation), a major systemic financial failure could occur. This could set off an unsolvable market labour imbalance, with rising unemployment, and severe income disparities. Failure to address this economic crisis impacts the ability to fulfil personal aspirations, could drive migration on a significant scale, trigger food and water shortages and amplify the impacts of climate change and extreme weather events.

3.6 Rampant vulnerability to natural catastrophes

Intense and repeated natural disasters of major scale could overcome our society’s capacity to deal with their consequences. Destructive climate change including rising sea levels could lead to massive destruction of infrastructure and loss of high-quality agricultural land in low-lying coastal areas and require relocation of entire populations. Vulnerability to natural disasters could develop into major humanitarian catastrophes, characterised by major threats to food security and large-scale epidemics.

This game-changer could trigger an adverse scenario where, following a disease outbreak triggered by a natural catastrophe, global travel enables the rapid spread of the epidemic across multiple continents. The rising rate of chronic diseases combined with the emergence of antibiotic-resistant bacteria could create particular vulnerabilities in a wide proportion of an increasingly urban population. Failure of the intellectual property regime could slow down the mobilisation of researchers and the discovery and distribution of possible cures. Higher mortality rates could be experienced in many countries and significant migrations originate from the disease areas.

3.7 Opportunities & risks from the inter-relations between drivers & disrupters

The interplay between the relatively well-understood and predictable path of the change drivers and the interference brought about by one or more of the six game-changers in this section has the potential to create serious risks and extraordinary opportunities.

The diagram overleaf represents the four scenarios described in sections 3.1, 3.2, 3.5 and 3.6 above in a visual way.

Whilst we can only scratch the surface of the ramifications, they are clearly game
changing. Rather than anticipate them all – in all likelihood, an impossible task - a better twin-track approach is to:

- improve continuously the capabilities needed in Europe to keep track of these evolutions
- and put in place the mechanisms to enable our society to be prepared for, and, in as much as feasible, benefit from these unpredictable changes.
Diagram 2: Cascade for four scenarios showing the inter-relations between disrupter and drivers

Disruptive Trigger | First order impact | Second order impact | Third order impact
--- | --- | --- | ---
Rise in religious fanaticism | Anti-Globalisation backlash | Cyber attacks | Large Migration
Disrupter and Driver Cascade | Data & identity thefts | Terrorist campaign | Religious Education Development

Evidence of acute corruption in institution | Governance failure | Commercial & Financial system failure | Supply chain disruption | Society breakdown

Unmanageable inflation | Financial system failure | Spiralling unemployment | Unfulfilled Personal aspirations | Water and sanitation

Rampant Vulnerability | Income disparities | Health Migration | Accelerated environmental degradation

Significant natural catastrophe (earthquake, eruption) | Outbreak of disease | Global travel spreads disease | Urban population effects | Mass Migration

Source: Vincent Rousselet & Associates
Part 4: Triggers for strategic responses in the second strategic programme of Horizon 2020

In the concluding part of this report, we examine possible strategic responses to the change drivers and disrupters can be in the context of the second strategic programme of Horizon 2020. Such responses would need to be focussed on the two primary objectives of Horizon 2020 namely to:

- improve the economic competitiveness of Europe; and
- enhance the ability of Europe to offer resilient services to its citizens, especially in the domains of the societal challenges explicitly addressed by Horizon 2020.

The selection of triggers developed here reflects the high level construction of drivers of change, the functioning of the disrupters and the relevant discussion in the workshop of 10 December 2013. The list is therefore indicative, rather than comprehensive. The triggers are loosely clustered in three categories:

- Cross-cutting issues such as population and globalisation
- Technology-related issues which, in combination, point to a radical digital transformation of our society based on hyper-connectivity
- Environment-related issues

4.1 Population changes, migration and ageing

Anticipating the effects of population changes and taking appropriate action to capitalise on the positive and prevent or minimise the expected negative impacts, particularly social and economic, is a top priority. The main challenge posed in Europe by this driver is the gradual ageing of the population. This is usually seen as a threat, although the health expert panel gathered as part of the project workshop did point out that older citizens can, and do, contribute to the economic and social well being of Europe. This contribution is an area which, currently, is not well understood or quantified.

The discussion of policy related to population brings together social, economic and cultural considerations, and often centres on the necessary level of controls over migration. Relevant observation and control practices and technologies, as well as facilitation of social integration activities form potential policy targets.

More important is the space shaped by the cross-over between the population, environment, urbanisation and healthcare drivers. Its examination reinforces the global nature of many of the challenges facing Europe. The WHO, for example, ensures the continued networking of medical research laboratories globally who, upon the discovery of a new pathogen, can be mobilised urgently to work collectively on generating and distributing a cure vaccine.

At the same time the risk of catastrophic emerging epidemics is not eliminated, as poverty and environmental degradation increase the risks of new health threats. Efforts must therefore be targeted at exploiting the opportunities created by the
conjunction of health, ageing, the environment and social conditions. Horizon 2020 can focus investment in technology areas which directly intervene in mitigating the effect of this ageing trend on European citizens (i.e. assistive technologies based on robotics; development of treatments for age-related diseases).

An additional strategic response should be in supporting social interventions that have an indirect effect on this trend, by combating the sense of isolation and personal loneliness experienced by older people. Supporting e-health and tele-medicine solutions, for example, can improve the ease of access to social services of increasing value to older generations, and strengthen personal confidence.

A further aim could be to exploit opportunities emerging from multiculturalism, and from worldwide population changes. These can benefit Europe’s economy and counteract the negative economic trends at play in the region.

4.2 Globalisation and fragmentation

Globalisation advances continuously, but at different speed in different areas and aspects. Reactions to it reveal the limitations of the process. Globalization is associated with economic growth and increasing affluence. However, increasing inequalities are seen as a negative consequence of globalisation and challenge social inclusion. In parallel to globalisation, there are processes of fragmentation (exemplified at an institutional level by the centrifugal trend in the creation of new countries, such as Catalonia and Scotland) and rising alternative systems and models (examples include uses of telecommunication infrastructures in Africa; human-technology interfaces in health; the culture of sharing in the West etc.)

This changes the structure and nature of economic and innovation opportunities around the globe (e.g. opening the agenda to “leapfrogging” processes and to a restructuring of production processes and supply chains). The process of fragmentation may increase the available technological variety with benefits for all. It can create new spaces for innovation and entrepreneurship. It also may provide opportunity for policy experimentation, for instance to address issues of “climate change” or “coupling the economy with the limits of the planet”, that require economic functions and models that are still in the sphere of visions.

There are two potential responses from Horizon 2020 that can be pointed at. First, it could help feeding intelligence and knowledge of worldwide phenomena (new emerging alternative systems) into R&D and innovation activities that would enable companies to correctly anticipate trends in potentially important new markets and technologies. Second, it could enable innovation experimentations that take advantage of emerging alternative systems, e.g. in the form of supporting SME and innovative business environments in such systems.

4.3 High expectations attached to new technologies
The rate of technological progress is not linear. For innovations which took 100 years to surface in the past, 10 or 20 years may suffice in the future. For this reason, many actors have already assumed the advent of future discoveries, reasoning that they are bound to occur, and so is their positive impact.

That future technologies will solve many intractable problems humanity faces today may prove true. However, this heightened expectation placed on innovation is susceptible to risk: thorny issues (nuclear waste disposal, climate change, use of technology by terrorist groups, species extinction to name but a few) may remain and may even multiply as the pace of innovation accelerates. Reaping the benefits of innovation and technology in the future will depend on our ability to embed them properly in social contexts.

From that perspective, public authorities have an important role to ensure that there is appropriate expertise and knowledge available to enable them to “regulate out” negative technological surprises, and that the development of technology keeps up with social and economic expectations.

In view of the manifold unknown side- and secondary effects of these emerging technological opportunities, it will be essential to ensure a critical monitoring of their further deployment, and take responsible and corrective action as needed.

A further question is posed by the increased use of robots in the manufacturing of goods and the provision of services. The growing role of machines throughout our social, personal and economic interactions creates an uncertainty, in the medium to long term. Advanced automation is likely to challenge our notions of work in a major way, raising very important political, economic and policy issues.

4.4 Transversality in new technologies and individualism

The acceleration of technological convergence provides an increasing ability to deliver transversal service platforms cutting across established sectoral boundaries combining infrastructures and technology, which enable the delivery of individualized services to users through higher system responsiveness and intelligent user-interfaces. This is a powerful enabler which is reinforced by “personal aspirations and empowerment“.

Conversely, innovations increasingly succeed in reaching wide adoption, as a result of tranversality, as using the technology is made simpler for the user by layering on top the very complex components a simple and intuitive interface. This is exemplified by the take-up of consumer products such as the iPhone. Usability and user interface in service provision are of critical importance and, deployed effectively, can generate competitive advantage.

Developing and operating transversal platforms requires new mixes of competencies, capabilities and modes of thinking, as production organization and supply chains can be potentially restructured in major ways. Transversality has major implications for
infrastructures. As such, it may inspire high-impact innovation in economy and society, and this makes it an important target.

4.5 IT, connectivity and networks

The application of networked IT brings important innovations to healthcare, space, globalisation, knowledge creation and urbanisation. IT is now part of the ‘fabric of society’ and it is critical for Europe to encourage the universal provision of connectivity – whether through mobile or fixed technology - and of increasing bandwidth to all its citizens and economic actors. This is both a telecom policy issue and a technology innovation issue, as full geographic coverage tends to hit cost barriers. The boost in competitiveness, and social inclusion from this access, however, cannot be overstated.

IT connectivity and infrastructure create competitive environments, where European economic actors face new competitors and partners in a virtual and globalised marketplace. This is a strong opportunity for European businesses to capture new revenue streams from customers they could not reach economically until now. It also brings new choices to European consumers who can choose goods and services from outside the EU with ever-increasing convenience.

Nevertheless, for all the promises a fully connected world holds, IT shapes huge challenges for our social models: advanced automation and employment; national identities and digital natives; a global financial system and cyber-crime, amongst others. Addressing this challenge requires global collaboration with private and public actors, both in Europe and in other regions of the world. Cyber-defence may be a space where Europe could coordinate relevant efforts of its member states.

4.6 Vulnerabilities are testing our resilience

The multiplication of extreme natural events is emerging as a strong trait of environmental and climate change. Natural catastrophes are a reality, not a possibility, for our society. Just like other continents, Europe requires better preparedness to these extreme events, to minimise their impact a priori and encourage multi-country collaboration in preparing for them.

Because extreme events could multiply, it is important for Horizon 2020 to move towards a higher systemic resilience, through better forecasting models supported by High Performance Computing and connected to better contingency plans.

In addition, more adaptation strategies and capacities are required to address the consequences of extreme events. Exploiting the knowledge of a partner such as Japan in this space should be invaluable.

4.7 Environmental changes and degradation

This driver is understood to tend towards negative outcomes, as recently reaffirmed
European Commission

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by the fifth assessment report by the IPCC. Efforts in Europe to reduce carbon emissions across a spectrum of domains (adoption of low or no-carbon energy sources, smart transport and agriculture techniques to cope with lower rainfall) are welcome steps.

Given the extent of environmental degradation to date, the focus of policies and strategic programmes has to be the coupling of adaptation and mitigation strategies to rectify the trajectory of this driver.

Environmental degradation has both natural and human sources. As it is a global phenomenon, Europe is not immune to changes taking place in other regions of the world. Extreme pollution may trigger significant migrations towards Europe, which could have an impact on security and stability. It is also important to consider how environmental changes impact the health and well-being of Europe’s population (for example in the spread of respiratory conditions in younger and older age groups or in abnormal mortality rates during very hot or very cold weather episodes).

Tackling degradation at the source will involve a change in behaviours among economic actors, which Europe must encourage, in order to reduce demand for goods and services which are polluting, or generate pollution during their production.

Geo-engineering should be considered with caution, to avoid over-optimism in this nascent domain. Development there will complement other measures, such as the development of renewable energy.

Horizon 2020 can also support the development of circular economy models and experimentation, especially where enabled by technology, as this will reduce demand and waste thanks to recycling and reuse.

4.8 Scarcity of resources and energy, and the search for new opportunity spaces

Resource scarcity is a global phenomenon, with the associated volatility and rise in purchase prices impacting all regions of the world. Tackling this issue requires international cooperation beyond Europe’s borders. Such a global outlook should be encouraged across all the strategic responses to this driver:

- Mitigation strategies to identify new technologies which lower the consumption of scarce resources, such as new lighter material used in cars and aeroplanes and more efficient combustion engines or renewable materials used in bio-based industrial processes.
- Adaptation strategies to develop new and economical sources of energy, for example tidal power from the oceans and seas around Europe, water and materials
- Breakthrough strategies, such as harnessing resources exploited in space to supplement similar resources coming to an end on earth.
Indeed, scarcities strengthen the search of new opportunity domains in new technologies. New technologies bring about two sorts of new opportunity spaces:

- First, they open new resources (such as those to be found in space or in the oceans) which until then could not be reached
- Second they also provide new advances and perspectives in sectors were precursor technologies are being used (e.g. synthetic foods, advanced robotics, large-scale 3D printing).

The development of fully synthetic food products, for instance, is seen as a remedy to population growth (outside of Europe) and resource scarcity. Advance robotics can transform manufacturing, space exploration, and healthcare. Nano-technologies and the development of new materials are all sectors where Europe has a degree of competitive advantage.

Finally, by taking a multi-disciplinary approach, Horizon 2020 can make better use of the opportunities created by multiple drivers converging. In the space formed by the interaction between driving factors (be they drivers or disrupters) Europe can identify ways to enhance prosperity and well-being within the planetary boundaries: thriving economies, flourishing societies, engaged communities and scope for personal fulfilment.
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## Appendix 2 – List of experts interviewed

<table>
<thead>
<tr>
<th>Name</th>
<th>Job Title</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof Luke Georghiou</td>
<td>Vice-President for Research and Innovation</td>
<td>Manchester Institute of Innovation Research</td>
</tr>
<tr>
<td></td>
<td></td>
<td>University of Manchester</td>
</tr>
<tr>
<td>Mr Thomas Reby</td>
<td>Former Head of Global Knowledge Management</td>
<td>eBay</td>
</tr>
<tr>
<td>Dr Joseph Reger</td>
<td>Global Chief Technology Officer</td>
<td>Fujitsu</td>
</tr>
<tr>
<td>Dr Lester Russell</td>
<td>Global Chief Medical Officer</td>
<td>Fujitsu</td>
</tr>
<tr>
<td>Dr Fabiana Scapolo</td>
<td>Team Leader Foresight and Horizon Scanning</td>
<td>Joint Research Centre European Commission</td>
</tr>
<tr>
<td>Dr Didier Schmitt</td>
<td>Scientific Adviser &amp; Foresight Coordinator</td>
<td>Bureau of European Policy Advisers European Commission</td>
</tr>
<tr>
<td>Mr Bruno Vaffier</td>
<td>Senior Vice President – Innovation</td>
<td>Atos</td>
</tr>
<tr>
<td>Ms Claire Vishik</td>
<td>Security and Privacy Standards and Policy Manager</td>
<td>Intel</td>
</tr>
<tr>
<td>Dr Angela Wilkinson</td>
<td>Strategic Foresight Counsellor</td>
<td>OECD</td>
</tr>
</tbody>
</table>
### Appendix 3 – Participants at Brussels Expert workshop

<table>
<thead>
<tr>
<th>Expert Name</th>
<th>Job Title</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olli Salmi</td>
<td>Research Professor, Industrial Ecology and Recycling</td>
<td>VTT</td>
</tr>
<tr>
<td>Rosario Macario</td>
<td>Assistant Professor of Transportation</td>
<td>Instituto Superior Técnico, Lisbon Technical University</td>
</tr>
<tr>
<td>Petra Keil</td>
<td>Head of Global Public Policy</td>
<td>Novartis</td>
</tr>
<tr>
<td>Kerstin Lindblad-Toh</td>
<td>Professor in comparative genomics</td>
<td>Uppsala University / Science for Life Laboratory</td>
</tr>
<tr>
<td>Lora Fleming</td>
<td>Centre Director</td>
<td>European Centre and Chair of Oceans, Epidemiology and Human Health, University of Exeter</td>
</tr>
<tr>
<td>Sirpa Kurppa</td>
<td>Professor</td>
<td>MTT Agrifood Research Finland</td>
</tr>
<tr>
<td>Sébastien Treyer</td>
<td>Director of Programmes</td>
<td>Institute for Sustainable Development and International Relations</td>
</tr>
<tr>
<td>Joergen Kjems</td>
<td>Renewable energy</td>
<td>National Laboratory for sustainable energy, Technical University of Denmark</td>
</tr>
<tr>
<td>Andy Deacon</td>
<td>Director of Development</td>
<td>Energy Saving Trust</td>
</tr>
<tr>
<td>Petra Hoepner</td>
<td>e-Government security applications</td>
<td>FOKUS</td>
</tr>
<tr>
<td>Lucia Gardossi</td>
<td>Associate Professor of Organic Chemistry</td>
<td>Trieste University</td>
</tr>
<tr>
<td>Rafael Bengoa</td>
<td>Director</td>
<td>DEUSTO Business School</td>
</tr>
<tr>
<td>Gianluca Brunori</td>
<td>Professor of agricultural economics</td>
<td>Pisa University</td>
</tr>
<tr>
<td>Calliope Panoutsou</td>
<td>Research Fellow</td>
<td>Imperial College Centre for Energy Policy and Technology</td>
</tr>
<tr>
<td>Andrea Ricci</td>
<td>Vice President</td>
<td>Instituto di studi per l’integrazione dei sistemi (ISIS)</td>
</tr>
<tr>
<td>Manuel Barange</td>
<td>Director of Science</td>
<td>Plymouth Marine Laboratory</td>
</tr>
<tr>
<td>Cristina Leone</td>
<td>External Relations, European Programmes</td>
<td>Finmeccanica Aerospace and Defence</td>
</tr>
<tr>
<td>Caroline Davey</td>
<td>Director</td>
<td>University of Salford, Design against Crime Solutions Centre</td>
</tr>
<tr>
<td>Augusta Maria Paci</td>
<td>Technologist Director</td>
<td>CNR, Chemical Sciences &amp; Materials Technologies Dept.</td>
</tr>
<tr>
<td>George Vekinis</td>
<td>Chief Researcher, Head of the Advanced Ceramics Laboratory</td>
<td>Demokritos</td>
</tr>
<tr>
<td>Daniel Kofman</td>
<td>Professor</td>
<td>Telecom ParisTech</td>
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<table>
<thead>
<tr>
<th>Name</th>
<th>Job Title</th>
<th>Organisation</th>
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<tbody>
<tr>
<td>Maarja Kruusmaa</td>
<td>R&amp;D Director</td>
<td>Tallin University of Technology</td>
</tr>
<tr>
<td>Gérard Brachet</td>
<td>Consultant</td>
<td>Sic Itur</td>
</tr>
<tr>
<td>Barbara Ghinelli</td>
<td>Director</td>
<td>Harwell Oxford Space Cluster, Science and Technology Facilities Council</td>
</tr>
<tr>
<td>Kai Peters</td>
<td>Adviser RTD</td>
<td>VDMA</td>
</tr>
<tr>
<td>Rüdiger Klein</td>
<td>Executive Director</td>
<td>ALL European Academies</td>
</tr>
<tr>
<td>Laura Burke</td>
<td>Director General</td>
<td>Environment Protection Agency</td>
</tr>
<tr>
<td>Danilo Bonato</td>
<td>Director General</td>
<td>ReMedia</td>
</tr>
<tr>
<td>Richard Hudson</td>
<td>CEO and Editor</td>
<td>Science Business</td>
</tr>
<tr>
<td>Ralf Engel</td>
<td>Scientific Advisor, Europe &amp; Partnerships</td>
<td>Ministère de l’Ecologie</td>
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**Commission Officials**

<table>
<thead>
<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Franco Accordino</td>
<td>Nikos Kastrinos</td>
</tr>
<tr>
<td>Jesus-Maria Alquezar-Sabadie</td>
<td>Barbara Kerstiens</td>
</tr>
<tr>
<td>Thomas Arnold</td>
<td>Artemios Kourtesis</td>
</tr>
<tr>
<td>Esperanza Arrizabalaga-Vena</td>
<td>Mats Ljungqvist</td>
</tr>
<tr>
<td>Elisa Boelman</td>
<td>David Mair</td>
</tr>
<tr>
<td>Jean-Claude Burgelman</td>
<td>Neville Reeve</td>
</tr>
<tr>
<td>Jarka Chioupkova</td>
<td>Domenico Rossetti di Valdalber</td>
</tr>
<tr>
<td>Marco Cortopassi</td>
<td>Fabiana Scapolo</td>
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<tr>
<td>Peter de Smedt</td>
<td>Cornelius Schmaltz</td>
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<tr>
<td>Nicholas Deliyanakis</td>
<td>Katerina Svickova</td>
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<tr>
<td>Maren Hanfeld</td>
<td>Stefaan Van der Borght</td>
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**Facilitator Name**

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<thead>
<tr>
<th>Name</th>
<th>Job Title</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gill Ringland</td>
<td>CEO and Fellow</td>
<td>SAMI Consulting</td>
</tr>
<tr>
<td>Vincent Rousselet</td>
<td>Director</td>
<td>Vincent Rousselet &amp; Associates</td>
</tr>
<tr>
<td>Matthias Weber</td>
<td>Head of Unit</td>
<td>Austrian Institute of Technology</td>
</tr>
</tbody>
</table>
### Appendix 4 – List and description of drivers of change

<table>
<thead>
<tr>
<th>Title of Driver</th>
<th>1. Population Changes, Migration and Ageing</th>
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</table>
| **Description**                                           | Total world population continues to grow to a likely peak of 9 billion by 2050, but it does so in an uneven way. The spread of education and affluence impacts on birth rates and longevity, which is also pushed by advances in health and medical care. Based on current birth and death rates, Europe is facing a rapidly ageing population in the short to medium term and a population reduction in many countries in the longer term.  
  
  Global population growth by 2050 is estimated to lead to a 70% increase in food demand, thus raising food security issues. The ageing population in Europe (and parts of Asia) is the cause of new economic and societal issues, as older people require specific healthcare and other services, particularly to address chronic diseases.  
  
  A reducing active population has to bear the cost of this larger, older group, thus challenging existing social models of solidarity and fairness. Increasing immigration and longer working lives are two of the most discussed, and most controversial, aspects of emerging new social models. Technology, economic and political factors continue to drive migration towards Europe, while receiving countries there often struggle to welcome and integrate these newly arrived individuals and their families. Immigrants settle in urban areas reinforcing the urbanisation of Europe. Within Europe, the free movement of people may exacerbate the tensions between affluent regions (in the north) and more economically fragile parts of the union (typically in the south). |
| **Related Drivers**                                       | Personalisation & Expansion of Healthcare; Environmental Changes and Degradation; Personal Aspirations; Urbanisation; Scarcity of Resources |
| **Related Disrupters**                                    | Values and Beliefs; Trust and Reputation; Tech Surprise; Conflict and Insecurity |
| **Potential disruptive factors**                          | accelerator(s):  
  • Increase in standard of living, expansion of healthcare, fewer hardships  
  • Increased access to knowledge and (tele)medicine (internet etc.)  
  • Increased mobility of people away from stagnant or undeveloped economies (PIIGS in the EU, some Asian or North African), inhospitable environments, and zones of war and catastrophe  
  • Ill-thought-of policies (e.g. 1 child policy in China) |
### brake(s):

- Increase in immigration from MENA into Europe (and from South East Asia into Japan and China) would mitigate the ageing population trend.
- Reduction in life expectancy due to rise in chronic diseases and possible emergence of uncontrolled pandemics.
- Food shortage and/or epidemic in certain countries may impact population growth, but at a high social cost.
- Policy-driven incentives e.g. encouraging extended family support and fiscal incentives may motivate parents to have more than 1 child.
**Title of Driver** | **2. Globalisation**
---|---
**Description and Implications** | A process of international integration covering increasingly the planet. Increasing movement of goods, capital, information, people and services around the globe, resulting from liberalisation of trade over the last half of the last century and the establishment of an almost global information and supply chain infrastructure. International trade as % of world GDP doubled between 1970 and 2010 (26% to 56%). The US$ and € account for 90% of the world’s currency reserves. Still only 9 of the Fortune 500 companies generate more than 20% of their revenues from 3 or more different continents.

Globalisation has led to the widening of economic opportunities. It has contributed to many countries "leap-frogging" out of extreme poverty, to the expansion in education and gender parity across society and to the development of transport and tourism on an unprecedented scale. The expansion of economic activity has had an impact on the environment and the global influence of regulations such as REACH and the Kyoto accords has resulted in environmental improvement (or at least sensitization). As more global governance structures develop there is a hope that the continuation of the globalisation trend will bring peaceful coexistence of peoples around the world.

Currently, globalization is associated with a shift of the centre of gravity for economic success towards new emerging countries especially in Asia, challenging the competitiveness of Europe and its technological lead in unprecedented ways. With continued GDP growth in BRICS and CIVETS economies at a higher rate than in the EU, relative GDP weight, prosperity and optimism are all rising in these fast-growing countries. The emerging economies’ share of Fortune 500 companies is expected to rise to more than 45 percent by 2025 (from 5 percent in 2000). From accounting for a third of G7 GDP in 2010, BRIC GDP heads towards surpassing the G7 in 2030-35. Demographic trends and technology advances (e.g. Brazil) continue to favour emerging economies. In the longer term, the economic rise of Africa could reinforce Asian-African cooperation and scale up Asian-African trade relations.

At a political level, the growing importance of emerging markets challenges the notion that democracy and economic growth are linked, which is a fundamental assumption of the European project.

As globalization continues what will happen to hegemonic powers? Will powers continue to be national or will they be supranational? Will they be democratic or autocratic? Will they be public or private?

While some see a shift towards networks and coalitions in a multi-polar world, with the US, China and Europe the three like poles of global power, countries with strong economic fundamentals—GDP, population size, currency reserves etc.—are keen to undertake more global roles.
At the same time, enabled by communications technologies, power also shifts toward informal networks and non-state actors. Cities, corporations and other entities will increase their influence on state and global actions. Civil society might gain increased influence on the shaping of policy and social networks will favour new forms of participation and the development of a globalized public opinion.

These changes affect not only the macro-aspects of governance, but also amplify the importance of deliberation and contribute to growing citizens’ engagement and participation. This in turn can lead to more tense political arguments, which can challenge recent or fragile democracies.

Globalization is not without risks as global interdependence increases followed by the shaping of governance mechanisms rather than being led by them. In the shaping of governance mechanisms (or in the absence of such mechanisms) there are winners and losers, and power, risks and benefits are unevenly distributed. Integration is accompanied by fragmentation, and economic and political crises coexist with increasing prosperity and opportunity. This fragmentation could engender antagonistic models of economic and social development and could evolve in open conflicts.

<table>
<thead>
<tr>
<th>Related Drivers</th>
<th>Education Revolution and gender equality; New &amp; Emerging Technologies; Changing Creativity &amp; Innovation; IT, Connectivity &amp; Networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related Disrupters</td>
<td>Values and Beliefs; Trust and Reputation; Crisis-prone Global Economy</td>
</tr>
<tr>
<td>Potential disruptive factors</td>
<td>accelerator(s):</td>
</tr>
<tr>
<td></td>
<td>• Liberalizing institutions and agreements (e.g. T-TIP, TPP)</td>
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<tr>
<td></td>
<td>• Stable foreign exchange and financial services context and increased reliability of global financial transactions</td>
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<tr>
<td></td>
<td>• Increased security, stability and reliability of communications, especially satellite (Galileo) and resulting increased reliability of transport tracking</td>
</tr>
<tr>
<td></td>
<td>• Positive influence of “common denominators” such REACH, Kyoto, the “law of the Sea”, the SWIFT payment system, various UN Global Technical Regulations for vehicles, materials, etc.</td>
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<tr>
<td></td>
<td>• Continued low/no growth in Europe (towards one lost decade since 2008 recession)</td>
</tr>
<tr>
<td></td>
<td>• Emergence of Trade Partnerships in the East and South (e.g. ASEAN)</td>
</tr>
<tr>
<td></td>
<td>• Stronger domestic demand reflecting the high aspirations of low average age population (China, Indonesia, Brazil)</td>
</tr>
<tr>
<td></td>
<td>• China and other BRICs developing excellence in Europe’s key competences of sustainable solutions and green technology, but also making fast progress where Europe is stagnating, such as in genetics.</td>
</tr>
</tbody>
</table>
Emerging national pride forges incentive to "catch-up" or "overtake" advanced economies
- Maintenance of low labour costs / weak labour regulations in many of these countries
- Export product dumping, unfair subsidies, weak enforcing of regulations etc.
- Fast economic growth in large emerging countries (e.g. Brazil, China)
- Continued investment in military and defence budgets
- Relevance of global diplomatic and economic institutions (UN, IMF, World Bank)
- Democratisation of China
- Economic groupings gradually become political ones as benefits become more obvious (EU, ...)

Brake(s):
- Political or social opposition manifested in protectionism
- Possible breakdown in trust towards financial, corporate and / or public institutions (e.g. weak enforcing of health, environmental or security regulations allowing dumping of goods)
- Legitimacy deficit in global and multi-national institutions (including the European Union). Inadequacy of global governance mechanisms resulting in fragmentation.
- Financial or political manipulations (Libor scandal, 2008 economic crisis, political interference in China etc., unfair lobbying, corruption, weak domestic consumption in Germany etc.)
- Unfair practices such as subsidies for exports, artificially low labour costs, weak enforcing of laws and regulations etc.
- Over-indebted states forced to artificially depress their economies within the Euro zone (PIIGS)
- Economic slowdown in China / India due to global demand weakness
- Social unrest within key Eastern economic powers
- Disillusionment due to depressed global economy
- Open or latent conflicts between main powers (economic or military) and Local territorial conflicts escalate into localised wars (e.g. Japan / Korea / China)
- Emergence of authoritarian regimes as a backlash of economic downturn
- Fringe political powers exert undue political influence because of weak governments
- Extensive manipulation of political power by corporations and other “behind-the-scenes” powers
### Title of Driver

| Description | Fast advances in medical treatments (such as genomics and bionic body & mind enhancements) are on the map to address the major problems faced by the healthcare sector (amongst which are ageing population and the rise of chronic diseases).

The convergence of technology and medicine will trigger innovation such as nano-robots, remote surgery and personalised drugs and diets without eliminating the risk of cost explosion and social exclusion.

Healthcare globally is characterised by intense collaboration and learning across national boundaries, with networks of medical laboratories able to be mobilised in near-real time to combat emerging challenges (new viruses, infections, epidemics etc.).

The enhancement of human capabilities that personalised healthcare promises will transform the meaning of life and the economics of healthcare service provision. However, public health challenges remain, rooted in unequal development (e.g. rise of poverty-related diseases), unhealthy lifestyles (e.g. rise of obesity), environmental degradation and misuse of current treatment (e.g. over-prescription of antibiotics or antidepressants). |

### Related Drivers

- Population Changes, Migration & Ageing
- Personal Aspirations
- New & Emerging Technologies

### Related Disrupters

- Values and Beliefs
- Trust and Reputation
- Tech Surprise
- Conflicts and Insecurity

### Potential disruptive factors

- Personal aspirations
- High profile positive impact of medical inventions (e.g. diagnostics, treatments), such as breakthrough in medical research (e.g. cancer cure) and eradication of major diseases (e.g. malaria)
- Bio and nano-technology applied to the enhancement of the human body
- Low cost of new health / medical treatments generated by the application of technology and / or generic medications at lower costs
- Supportive legislative / ethical framework enabling widespread adoption
- Increase access to knowledge and better communication, for example in wide deployment of Telemedicine
- Influence of medically-focused charities to solve specific medical problems in developing world
- Emerging challenges such as allergies and health problems due to sedentary lifestyles and work routine (also a brake)
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- Increased influence of women in traditional societies
  brake(s):
  - Healthcare costs rising in both developed and developing nations
  - Cost of new treatment prohibitive leading to reduced access to care and widening public deficit
  - Unresolved ethical issues (privacy, medicalization of the human body, genome mapping and storage, stem-cell research)
  - Vulnerability generated / exposed in human race by new generation of treatments
  - Unforeseen toxicity (e.g. of nanotechnology) and regulatory failure brings distrust or negative perceptions
  - Negative perceptions of regulatory and monitoring bodies as being in “cahoots” with big pharma (e.g. SARS scare & resulting over-purchase of antivirals)
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<table>
<thead>
<tr>
<th>Title of Driver</th>
<th>4. Environmental change and degradation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Environmental degradation is the reduction of the capacity of the environment to meet social and ecological objectives, and needs. Environmental degradation involves the destruction of natural habitats and the depletion of natural resources, especially water, soil and air as well as wildlife. Environmental change and degradation is both natural and man-made through use of environmental resources and waste production. Of a particular concern is the change in climate. Global warming and extreme weather patterns affect biodiversity, resources and human population as well as the global balance of power. Global warming is expected to be associated with rising rainfall which will precipitate soil erosion and result in significant environmental degradation. Models foresee that an increase of more than 2°C above the average global temperature since pre-industrial times will result in dangerous climate change, involving positive feedback loops that would accelerate warming that will in turn accelerate climate change. Some see dangerous climate change as already happening.</td>
</tr>
<tr>
<td><strong>Related Drivers</strong></td>
<td>Population Changes, Migration &amp; Ageing; New &amp; Emerging Technologies; Space Exploration &amp; Exploitation; Scarcity of Resources &amp; Energy</td>
</tr>
<tr>
<td><strong>Related Disrupters</strong></td>
<td>Tech Surprise; Conflict and Insecurity; Rampant Vulnerability</td>
</tr>
<tr>
<td><strong>Potential disruptive factors</strong></td>
<td>accelerator(s):</td>
</tr>
<tr>
<td></td>
<td>• Growth in demand for unsustainable food and energy sources</td>
</tr>
<tr>
<td></td>
<td>• Continued loss of soil fertility and biodiversity, increased water pollution</td>
</tr>
<tr>
<td></td>
<td>• Disturbed balance of marine and terrestrial ecosystems</td>
</tr>
<tr>
<td></td>
<td>• Political unwillingness to tackle the problem</td>
</tr>
<tr>
<td></td>
<td>• Economic downturn which has been used as an excuse for business as usual or even increase in emissions</td>
</tr>
<tr>
<td></td>
<td>• Government promises and personal aspirations for growth in BRICS and danger of social instability if attempts are made to restrict them</td>
</tr>
<tr>
<td></td>
<td>• Government policies of encouraging fossil fuel use (fracking in USA, Canada, UK, China, ...) in order to ensure self-reliance</td>
</tr>
<tr>
<td></td>
<td>• Slow development of clean base energy sources, especially fusion, possibly due to vested interests</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Brake(s):</th>
</tr>
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<tbody>
<tr>
<td>- Strengthening the environmental management capacity, and regulation against polluting technologies (REACH, vehicles, factories etc.) including stricter enforcing of environmental regulations worldwide</td>
</tr>
<tr>
<td>- Prolonged global recession reduces demand for energy and keeps CO₂ emission levels down</td>
</tr>
<tr>
<td>- Decisive policy choice in favour of low-carbon/renewable energy sources, Better monitoring and protection of the oceans and rain forests by satellites</td>
</tr>
<tr>
<td>- Deep and rapid change in western world consumer behaviour in favour of sustainable / low-carbon options</td>
</tr>
<tr>
<td>- Increased in efficiency and reduction in price of solar photo-voltaics and wind mills</td>
</tr>
<tr>
<td>- Growth in clean industries and reduction of primary heavy industries</td>
</tr>
<tr>
<td>- Increased efficiency and cleanliness of production processes</td>
</tr>
<tr>
<td>- New, easy and cheap recycling processes for building materials (cement, brick etc.)</td>
</tr>
</tbody>
</table>
### Title of Driver

#### 5. Personal aspirations and empowerment

| Description | Increasing affluence, access to education, access to technology and increasing capacity to do things and express oneself in policy, economy and society all go hand in hand with growing expectations for individual empowerment. Overall, re-defining the sense of self, which encompasses dimensions such as personal ambition, one’s preferred lifestyle and work / career trajectory, is becoming an important priority for many, especially in the younger generations (e.g. digital natives).

As science is increasingly able to predict what a person will do, hence seemingly reducing the individual freewill, individualism is on the rise, even in societies traditionally orientated towards the collective.

New attitudes rejecting ostentatious consumption are appearing due to the recession (in Europe) and to the fight against corruption (in parts of Asia) and a general understanding of the waste generated in over-consumption. Combined with the ability to share or lease services and products rather than own them, a new model of consumption centred on pay-per-use becomes established within a circular economy replacing the currently widespread “throw-away culture”.

<table>
<thead>
<tr>
<th>Related Drivers</th>
<th>Personalisation &amp; Expansion of Healthcare; Education revolution and gender equality; New &amp; Emerging technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related Disrupters</td>
<td>Values and Belief; Trust and Reputation; Conflict and Insecurity</td>
</tr>
</tbody>
</table>

| Potential disruptive factors | accelerator(s):
|-----------------------------|---------------------------------------------------------------|
|                             | Affluence
|                             | Education
|                             | Gender equality
|                             | Social entrepreneurship (e.g. community mobilisation, NGOs, petitions) based on human-centred, as opposed to profit-centred, approach to development
|                             | The rise of economic ethics and consumer awareness manifested by the drives for e.g. fairness and sustainability
|                             | Movement for direct democracy and the protection of fundamental human rights
|                             | Drive for gender balancing, multiculturalism and diversification of cultures
|                             | New economic models based on grass-roots cooperation aided by the internet, e.g. La Via Campesina (International... |
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| Peasants’ Movement) and other movements promoting food sovereignty
| The power of the online mobilisation of people to influence political and economic decisions
| brake(s):
| • Erosion of capability for mobility between economic classes (increasing polarisation)
| • Crisis of confidence in main faiths (e.g. Catholic church scandals, split of Anglican church, sunni / chia’ tensions played out in middle east civil conflicts)
| • Rise of fundamentalist ideologies
| • Apparent public apathy and political tolerance concerning the rise in mass surveillance, intrusion into privacy and diminution of personal liberty
### 6. Urbanisation

<table>
<thead>
<tr>
<th>Title of Driver</th>
<th>Description and Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urbanisation</td>
<td>Urbanisation is a global trend with over half of the world population now living in cities. Rapid growth of mega-cities is experienced outside of Europe, particularly in Asia and Latin America. In Europe, 80% of the population will be urban by 2050. The concentration of the headquarters of large organisations (both public and private) in cities is a major contributor to continued urbanisation. Environmental and energy-efficiency considerations favour urban lifestyles, while the dependence of urban life on infrastructure, transport and logistics can challenge food availability, induce new vulnerabilities and require new answers to enhance resilience of urbanized areas. At the same time, the development of the bio-economy and its potential to create new and diversified jobs in rural and coastal areas could favour a more balanced urban-rural development and interface.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Related Drivers</th>
<th>Population Changes, Migration &amp; Ageing; Environmental Change &amp; Degradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related Disrupters</td>
<td>Values and Beliefs; Trust and Reputation; Crisis-prone Global Economy</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Potential disruptive factors</th>
<th>accelerator(s):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Reduction in rural public services &amp; agricultural funding policy can accelerate further the rural exodus towards cities</td>
</tr>
<tr>
<td></td>
<td>• Improvement in public transport, social infrastructure and communication network in cities</td>
</tr>
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<td></td>
<td>• Social and quality of life perceptions highlighted by TV etc. and better access to communications, schooling, internet, healthcare, jobs etc.</td>
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<tr>
<td></td>
<td>• Increased disruption of life by more frequent weather instabilities due to global warming</td>
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<table>
<thead>
<tr>
<th></th>
<th>brake(s):</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>• Rise in pollution and health issues caused by over-urbanisation</td>
</tr>
<tr>
<td></td>
<td>• Impact of climate change on coastal cities increasing the risk of flood</td>
</tr>
<tr>
<td></td>
<td>• Realisation of the impact of sedentary or urban living on health drive city-dwellers to relocate</td>
</tr>
<tr>
<td></td>
<td>• Reduction in urban jobs and decreased quality of life (stress, commuting, air pollution), pushes people to relocate to the country</td>
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<tr>
<td></td>
<td>• Internet-enabled work-from-home, incentivises people to relocate to the country combined with higher urban cost of living (esp. housing) or cost instabilities</td>
</tr>
<tr>
<td></td>
<td>• Telemedicine, tele-schooling, social media, better communications, satellite cover, teleworking all allow / encourage people to relocate</td>
</tr>
</tbody>
</table>
**Title:** 7. Education Revolution and Gender Equality

**Description and Implications:**

Education is a fundamental factor in development and societal progress, enabling literacy and facilitating the integration of individuals in society in general and in employment in particular. Currently public education systems are achieving almost global literacy with the exception of some African countries. In 2010 84% of global population could read and write.

Education is undergoing significant transformations resulting from the changing needs of social integration and employment in an increasingly globalized society and from the influence of technology, enabling increasingly personalized and tailored learning experiences. Almost one third of all US students enrolled in postsecondary education took an online course for credit in fall 2011 (6.7 million up from 1.6 million in 2001). The Distance and E-Learning Network created in 1991 includes now 420 institutions.

A current wave of educational innovation is linked to the availability of short courses that can be selected to fit the needs of individual users, especially in the field of adult education. Literacy becomes only part of the target of public education systems to enable the core skills of social integration. In the medium-term the drive towards effective flexible life-long-learning could replace the drive towards global literacy, which could, by and large, be achieved. In the longer term the drive towards personalization of learning enabling integration in society will continue, through new, better and more flexible infrastructures. Combined with gender equality, education contributes greatly to the containment of population growth. Women still make up two-thirds of all non-literate worldwide. Increase in education amongst girls leads to advances in income, higher status in society and access to the job market at a higher level of responsibility. This plays a significant role in population trends through birth control and better family planning education.

**Related Drivers:**

- Personal aspirations; Changing Creativity & Innovation

**Related Disrupters:**

- Values and Beliefs; Trust and Reputation; Crisis-prone Global Economy

**Potential disruptive factors:**

- Rise in literacy to 100% (84% of the global population is literate in 2010, vs. 74% in 2001)
- Affluence, economic growth
- Growth in initiatives such as One Laptop per Child (launched in 2005 – 2.4 million units by 2011)
- Expansion of European Distance and E-Learning Network
- Widespread legislative framework to compel gender parity in business and public sector and combat discrimination
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<table>
<thead>
<tr>
<th>and gender-specific violence</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Additional control for women over their fertility and additional options for men e.g. new contraceptive drugs and rules</td>
</tr>
<tr>
<td>• Greater public and legal acceptance of alternative familial and living arrangements e.g. single parent families</td>
</tr>
<tr>
<td>• Increased implementation of flexible working arrangements e.g. flexitime, teleworking</td>
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<tr>
<td>• Greater acknowledgement of benefits of more proactive, inclusive representation of women in the media, educational curriculum etc.</td>
</tr>
<tr>
<td>• Internet and social media as a communication and mobilisation platform</td>
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<tr>
<td>• Increased opportunities for economic participation esp. in rural and underdeveloped areas through e.g. micro-financing</td>
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<tr>
<td>• Increased support for NGOs, charities and public initiatives focusing on women</td>
</tr>
<tr>
<td>brake(s):</td>
</tr>
<tr>
<td>• Persistence of cultural and religious norms which promote existing inequalities in e.g. education</td>
</tr>
<tr>
<td>• Education used to promote conservative anti-learning ideologies.</td>
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<tr>
<td>• Increased need for women to stay at home to look after the elderly &amp; persistence of stereotyped gender roles e.g. in education &amp; the professions</td>
</tr>
<tr>
<td>• Reduction in welfare support e.g. child care, shelters, clinics, libraries</td>
</tr>
<tr>
<td>• Persistence of the perception of discriminatory and sexist behaviours in the workplace, home, school environment etc. as being normal</td>
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</table>
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<table>
<thead>
<tr>
<th>Title of Driver</th>
<th>8. New and Emerging Engineering Technologies and Practices (including geo-engineering)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The combination of various scientific and technological fields is bringing new applications which are adopted widely across society with balanced share of benefits and holds the promise of radical improvements in a wide array of domains, such as the penetration of 3-D printing technology revolutionising manufacturing, health and service industries.</td>
</tr>
<tr>
<td></td>
<td>Technological convergence (facilitated by IT) provides an increasing ability to deliver transversal service platforms, combining infrastructures and technology and cutting across established sectoral boundaries. A key direction is towards hiding technological and/or organizational complexity behind intelligent interfaces which enable higher system responsiveness to individual needs and delivery of a more individualized service to the end user. This trend provides an opportunity space for rethinking and restructuring global supply chains, and is therefore critical for the competitiveness of all industries. Developing and operating transversal platforms would require new mixes of competencies, capabilities and modes of thinking. Efforts to support transversal thinking include the promotion of inter-disciplinarity.</td>
</tr>
<tr>
<td></td>
<td>Changes in manufacturing which go beyond the purely technical aspects (such as production-consumption 2.0 and Industry 4.0) need to be taken into account. A stronger role claimed by users and the essentially decentralised nature of new technology (such as 3-D printing, distance learning or tele-medicine) bring a systemic change to the process of production, education and healthcare.</td>
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<tr>
<td></td>
<td>Biotechnologies can help increase crop yield, reduce crop vulnerability to environmental stresses and / or increase the nutritional value of foodstuff in order to address agricultural challenges related to food shortage. Bio-based industries can replace increasingly fossil-based industrial products or energy and help to alleviate land shortage issues.</td>
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<tr>
<td></td>
<td>New models for sustainable food production might help to reconcile food security with environmental protection, at the same time as broaden the base for access to food and increase consumer trust in the food chain. New technologies will also enable the creation of totally artificial food from non-biological sources and will require a new generation of food regulation.</td>
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<td></td>
<td>Geo-engineering is one example of an emerging technology. Geo-engineering is recently being discussed as part of a climate-change mitigation strategy for CO₂ removal (hence reducing greenhouse gases) and solar radiation management to</td>
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<table>
<thead>
<tr>
<th>Potential disruptive factors</th>
<th>accelerator(s):</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>ICT: Advances in processing power / chip performance and energy consumption; Progress in analytics and their applications (new generation expert systems for medicine, work, schooling...); Progress in virtual reality, augmented reality, engineering simulations, graphics...</td>
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<tr>
<td></td>
<td>Investment in R&amp;D</td>
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<td>Innovation friendly regulation</td>
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<td></td>
<td>New, stronger, tougher more functional enabling materials, in combination with better information give more choices to chemists, engineers and architects for extreme applications (e.g. mile-high buildings, fusion reactor, ultra high speed rail, ultra low friction bearings, higher efficiency engines, new energy production, new chemicals)</td>
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<tr>
<td></td>
<td>Intelligent factories increase efficiency and reduce waste</td>
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<tr>
<td></td>
<td>New generation nano-structured (flexible) photo-voltaics and fuel cells for energy production</td>
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<tr>
<td></td>
<td>New batteries etc. for energy storage spurs further application of renewables</td>
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<td></td>
<td>Use of application programming interfaces (APIs) and Open Source software development</td>
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<td></td>
<td>Cloud computing platforms, where IT Infrastructure is layered beneath Platforms themselves accessible via Software as a Service</td>
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<td></td>
<td>Application of inter-disciplinarity to major health and environmental challenges (e.g. AIDS, Alzheimer, global warming)</td>
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<td></td>
<td>Technological breakthrough in advanced breeding of key global crops (such as wheat or rice) or creation of entirely artificial food</td>
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<td></td>
<td>Regulatory regime which is favourable to advanced breeding techniques</td>
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<td></td>
<td>Advanced bio-refineries become commercially viable</td>
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<td></td>
<td>New promising sources of biomass (algae) and deep-sea resources become available</td>
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<td></td>
<td>Repetitive food shortage and associated civil unrest (such as food riot) encouraging the acceptance of GM</td>
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</table>

Impact climate change. However, geo-engineering has been traditionally part of approaches for adapting to environmental threats, such as the threat of flooding in low-lying countries. The deployment of geo-engineering solutions to environmental problems depends greatly on the trust that local communities can have and the assessment of the impact of geo-engineering works.

Related Drivers
- Personalisation & Expansion of Healthcare;
- Environmental Change & Degradation;
- Space Exploration & Exploitation;
- Changing Creativity & Innovation;
- IT, Connectivity & Networks;
- Scarcity of Resources and Energy

Related Disrupters
- Tech Surprise;
- Crisis-prone Global Economy;
- Rampant Vulnerability
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- Development of palatable artificial food (meat etc.)
- Competition between food and energy crops spurs development of new technologies
- Lack of R&D investment
- Rise in pollution / new kinds of pollution / resulting from ultrafine particles emission from 3-D printers, diesel engines etc.
- Reluctance from manufacturers to adopt / support technologies which impact their installed base / competitiveness / skills base
- Ill-thought-of or rushed applications of new technologies (resulting in real or perceived damage) may cause backlash against technology (e.g. nuclear power, GM, environmental pollution etc.)
- Public concerns and opposition: worries about robots “going crazy”; opposition to biotech, the genetic revolution, and novel food; GM crops affect nearby normal crops leading to negative impressions
- Battle of ecosystems between Apple, Google, Microsoft and Amazon - for domination of music, content and software application markets
- Public opposition to very expensive, large scale technological installations (CERN, Fusion ITER, Space exploration) in a time of economic downturn due to affordability
- Increased prices for food as a result of agricultural emphasis on energy (or commodity) crops
<table>
<thead>
<tr>
<th>Title of Driver</th>
<th>9. Space Exploration and Exploitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Space is already used today in a range of applications, such as communication and environmental &amp; military observations. Only a small fraction of the possibilities offered by space are known or exploited, while space technology makes significant contributions to the improvement of the performance of technologies and services on earth. However, pushed by diminishing resources and energy sources on the planet, we are seeking to explore and exploit the theoretically infinite reserves of other planets in materials / minerals / energy / etc. This is enabled by advances in robotics (for unmanned space mission) and space exploration techniques, including fuel and communication. Space exploration creates conditions for potential open conflict between state actors aiming to discover and control part of space.</td>
</tr>
<tr>
<td>Related Drivers</td>
<td>New &amp; Emerging Technologies; IT, Connectivity &amp; Networks</td>
</tr>
<tr>
<td>Related Disrupters</td>
<td>Tech Surprise; Rampant Vulnerability; Conflict and Insecurity; Tech Surprise</td>
</tr>
<tr>
<td>Potential disruptive factors</td>
<td>accelerator(s):</td>
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<tr>
<td></td>
<td>• Proven resources of valuable materials confirmed in planets close to Earth and in nearby solar systems</td>
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<tr>
<td></td>
<td>• Exhaustion of valuable resources on Earth (due to natural or human cause – such as climate change)</td>
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<tr>
<td></td>
<td>• Progress in adaptation and protection of humans living in space</td>
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<td></td>
<td>• Advances in robotics and robot spacecraft reduce challenges in space explorations</td>
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<tr>
<td></td>
<td>• Development of easier / cheaper methods for earth-return capsules carrying valuable materials</td>
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<td></td>
<td>• New space radiation shielding materials spur human exploration</td>
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<td></td>
<td>• Technology breakthrough in space travel / fuel efficiency (e.g. better catalysts for H₂O₂ dissociation allows for use in main rockets) brake(s):</td>
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<tr>
<td></td>
<td>• Discovery of further reserves on earth (e.g. sea-bed) or more efficient production approaches (e.g. water) reducing the risk of scarcity / exhaustion</td>
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<td></td>
<td>• Development of high efficiency recycling and re-use technologies reduce the incentives</td>
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<td></td>
<td>• Development of substitutes for critical materials reduces incentive</td>
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<td></td>
<td>• Protectionism practices by critical resource-rich nations (e.g. rare earths in China, platinum in S. Africa) spur new explorations or re-activation of older mines with “strategic subsidies” (Japan, EU and US)</td>
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<tr>
<td></td>
<td>• Space governance issue (national claim on a section of space and / or planet)</td>
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<td>• Cost of and/or disaster related to space exploration programme leading to public opinion reluctance to continue with</td>
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<tr>
<td>Space exploration</td>
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<tr>
<td>• Severe toxicity and environmental impact of main rocket fuels (hydrazine etc.)</td>
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<tr>
<td>• Spiralling costs and risks (accident in space)</td>
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<tr>
<td>• Health effects of space radiation or lack of gravity more serious than anticipated</td>
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</table>
**Title of Driver** | 10. Changing Creativity and Innovation  
**Description** | The increase of open innovation agreements between multiple actors challenges traditional models of IP ownership. The growth in inventions being generated, at least partially, by machines and computers opens new possibilities. New models emerging across various industries (such as pharmaceuticals, media and luxury goods) seek to re-define the value of creativity (in the form of patents and content).  
Access to knowledge (not least enabled by IT & Connectivity), growing role of entrepreneurship culture, changes in personal identity and identification with community interests/values rather than individual interests only all contribute to a fundamental shift in creativity.  
US patent applications have more than doubled between 1998 and 2012 to exceed 560,000 and new countries, such as China and South Korea are receiving and granting an increasing amount of patents. The rise in the absolute number of new innovations launched every year also creates the risk of each innovation being perceived as less valuable.  
**Related Drivers** | Personalisation & Expansion of Healthcare; Personal Aspirations; Education revolution and gender equality; New & Emerging Technologies; IT, Connectivity & Networks  
**Related Disrupters** | Values and Beliefs; Trust and Reputation; Crisis-prone Global Economy  
**Potential disruptive factors** | accelerator(s):  
- Open source innovation tools and shared ownership models become widely adopted  
- New forms of collaboration and sharing of big data allow new scientific and technological breakthroughs (e.g. in genomics or phenomics)  
- Internet-enabled collaboration between innovators and inventors leading to breakthrough discoveries and/or inventions  
- Interdisciplinary collaborations (e.g. between scientists, technologists, creative artists, philosophers, sociologists etc.) lead to new inventions  
- Global or local challenges spur the inventions of globally or locally significant innovative solutions (e.g. global communications satellites, VOIP communication, water-bottle light for slum communities, wind-up or solar mobile telephone charger...)  
- Interactive educational modes and approaches which encourage critical and inspiring thinking lead to new inventions
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<table>
<thead>
<tr>
<th>and / or discoveries</th>
<th>brake(s):</th>
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<tbody>
<tr>
<td>• “Critical necessity is the mother of invention”: the more severe the problem the greater the mobilisation of resources for its solution</td>
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<tr>
<td>• Internet and social media inspire and mediate social and human-centred creativity</td>
<td></td>
</tr>
<tr>
<td>• Outreach (careers fairs, workshops, open-days, mentoring and networking...) activities by businesses and institutions encourage and inspire inventiveness and innovativeness</td>
<td></td>
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<td>• Inspirational media programmes encourage inventiveness</td>
<td></td>
</tr>
<tr>
<td>• Creativeness inspired by traditional knowledge and practices in medicine, financial, manufacturing etc.</td>
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</tr>
<tr>
<td>• Continued copyright infringements and high profile legal cases tighten attitudes and fuel protectionist tendencies</td>
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<tr>
<td>• Awarding of wide-application generic patents suppress innovativeness</td>
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<tr>
<td>• Apathy, passivity and non-productive interaction suppress creativeness</td>
<td></td>
</tr>
<tr>
<td>• Passive or repressive educational systems</td>
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<tr>
<td>• Economic depression and lack of opportunities and support structures suppress innovations</td>
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</tr>
<tr>
<td>• Inadequate recognition and sharing of benefits of inventions suppress creativeness within institutions and companies</td>
<td></td>
</tr>
<tr>
<td>• Conservative attitudes by industry, business and government and vested-interests (competitors) do not allow the development of innovations</td>
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</tr>
<tr>
<td>• Reluctance of current knowledge owners to move from classical knowledge protection to new knowledge sourcing modes</td>
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</table>
### Title of Driver
11. IT, Connectivity and Networks

<table>
<thead>
<tr>
<th>Description</th>
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<tbody>
<tr>
<td>With abundant bandwidth and devices, commerce, trading as well as social and business interactions become increasingly virtual, potentially negating the need to commute, travel (with positive effect on carbon emissions) or meet real people (with negative impact on mental and social health). Penetration of new technology such as telepathy and holographic communication revolutionise manufacturing, health and service industries. As people and machines connect through mobile devices and implanted chips (50 billion machines could be connected by 2030), an avalanche of data is gathered, stored and analysed. This increases the risk of security and privacy breaches whilst holding the promise a safer, simpler world for individuals. Overall, this driver is highly reliant on trust. ICT is becoming part of the fabric of society and drives the generation of knowledge (e.g. “Science 2.0”).</td>
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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Globalisation; Personalisation &amp; Expansion of Healthcare; Urbanisation; Global Education Revolution and gender equality; New &amp; Emerging Technologies; Space Exploration &amp; Exploitation</td>
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<tr>
<th>Related Disrupters</th>
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<tr>
<td>Values and Beliefs; Trust and Reputation; Crisis-prone Global Economy; Tech Surprise; Conflict &amp; Insecurity</td>
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<table>
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<tr>
<th>Potential disruptive factors</th>
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</thead>
<tbody>
<tr>
<td>accelerator(s):</td>
</tr>
<tr>
<td>- Trust and security</td>
</tr>
<tr>
<td>- Advances in processing power / chip performance and energy consumption</td>
</tr>
<tr>
<td>- Mobile penetration exceeding human population</td>
</tr>
<tr>
<td>- Progress in analytics and their applications (e.g. advanced cognitive systems)</td>
</tr>
<tr>
<td>- New uses for multi-connected systems in health, security, weather prediction, food and water resource management etc.,</td>
</tr>
<tr>
<td>brake(s):</td>
</tr>
<tr>
<td>- Concern about a de-humanised world and privacy invasion</td>
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<tr>
<td>- Cybercrime and insecurity</td>
</tr>
<tr>
<td>- Reluctance from manufacturers to adopt / support technologies which impact their installed base / competitiveness</td>
</tr>
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</table>
## 12. Scarcity of Resources and Energy

**Description**
The collision of population growth, the rise of the middle class globally and climate change creates overwhelming pressure on food, water, materials and energy reserves. On current speed and course, some observers estimate that two planets will be needed to sustain the Earth’s population in 2050. Unsustainable production systems in place today risk of jeopardizing the planet’s capacity to produce food in future. The bio-economy could be a major part of a more sustainable and prosperous future within the boundaries of the planet and requires responsible and sustainable development. Various forecasts and scenarios predict that peak oil is still likely to happen, if later than originally anticipated and constrained by technology costs and environmental risks (related to fracking for shale gas for example) rather than natural reserve limits. A number of developed economies have also experienced (or are at risk of experiencing) power blackout as temporary energy demand exceeds supply.

Due to Europe’s high dependence on imports, there is also growing concern about the supply of particular materials. The EU-14 are materials on which the European economy depends but which might be at risk of supply disruptions. Supply disruption could be feared if one country exerts a monopoly of supply (e.g. China for Rare Earth Elements) or because the mineral is mainly produced in a politically or economically unstable region (e.g. tantalum from the Democratic Republic of Congo). Within a circular economy based on recycling by design, waste streams become a precious resource to develop new products. With the recognition of restricted planetary boundaries, there is growing attention given to greening the economy.

**Related Drivers**
Population Changes, Migration & Ageing; Environmental Change & Degradation; Space Exploration and Exploitation

**Related Disrupters**
Values and Beliefs; Trust and Reputation; Crisis-prone Global Economy

**Potential disruptive factors**
- Acceleration in demographic growth – particularly in water-stressed regions
- Erratic weather patterns (such as flood, drought, typhoon)
- Continuation and further global spread of unsustainable Occidental consumption patterns
- Path dependency, with difficulties to escape lock-ins in high-carbon technologies
- Difficulties in recycling or recovering critical materials (e.g. rare-earths)
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<table>
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<tr>
<th>Brake(s):</th>
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<tbody>
<tr>
<td>Geopolitical tensions, instabilities (e.g. wars, political) or economic boycotts result in artificial scarcities of materials</td>
</tr>
<tr>
<td>New indicators taking into account the overall footprint of production and consumption, and the benefits provided by ecosystem services</td>
</tr>
<tr>
<td>Technology advances in synthetic food production</td>
</tr>
<tr>
<td>Growth in alternative (especially non-fossil) fuels as key sources of energy</td>
</tr>
<tr>
<td>Gas and coal to liquid fuel transformation becomes cheap and easy</td>
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<tr>
<td>New, cheap and efficient processes for recycling and re-use of water</td>
</tr>
<tr>
<td>New, high efficiency and cheap recycling methods for critical materials</td>
</tr>
<tr>
<td>Rubbish-to-gas processes become widespread</td>
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<tr>
<td>New discoveries of lower-impact fuel reserves such as gas</td>
</tr>
<tr>
<td>Large scale methods for recovering methane from hydrides, clathrates and natural emissions from Arctic and Siberian areas</td>
</tr>
<tr>
<td>New, large-scale catalytic methods for producing hydrogen from CO2+CH4 emissions via dry reforming reactions</td>
</tr>
<tr>
<td>Methods for mining asteroids become cheap and easier</td>
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</table>
Appendix 5 – List and description of disrupters

<table>
<thead>
<tr>
<th>Title</th>
<th>A. Values and Beliefs</th>
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<tbody>
<tr>
<td>Description</td>
<td>Values drive the personal conduct of individuals and, in aggregate, that of economic actors. The internet provides a space where communities and value systems emerge that connect people who live in very different parts of the world. At the same time, an opposing trend sees the increasing financialisation of society and the economy. More interactions, which had traditionally been free, are becoming transactions, with an overt or covert cost and return. The notion of outcome (for patient, student, consumer and citizen) and reward are pervading our daily lives. All the while, the financial services sector accounts for an increasing percentage of economic value in mature economies. Migration changes the make-up of religious beliefs and personal values of the population in many countries, resulting in more fragmented multi-cultural societies. This fragmentation challenges conceptions of universal global values.</td>
</tr>
<tr>
<td>Significance</td>
<td>A sudden polarisation in values would trigger contradictory behaviours and create tensions. On the other hand, the natural evolution of values and beliefs enables the development of new value systems in an on-going dynamic process, which can have positive or negative results.</td>
</tr>
<tr>
<td>Related Drivers</td>
<td>Globalisation; Personalisation &amp; Expansion of Healthcare; Population Changes, Migration &amp; Ageing; Urbanisation; Environmental Changes &amp; Degradation; IT, Connectivity &amp; Networks; Scarcity of Resources &amp; Energy</td>
</tr>
<tr>
<td>Emerging changes and new values</td>
<td>• Changes in the nature of human interaction through the rise of the internet and social media • Changes in human aspirations and expectations and in the perception of personal capabilities chiefly through technology • Acceptance of the right to empowerment for minority groups, including self-assertion • Strengthening of the belief in technology to solve human problems and challenges (e.g. space exploration, climate change, medicine) • Willingness of a large percentage of the population to disseminate their personal information through social media • Continued disillusion with capitalist model of economic development reduces further consumers’ appetite</td>
</tr>
</tbody>
</table>
for over-consumption

- Rise of global super-rich class driving aspirations of the new middle-class in emerging countries
- Continued advances in computing and networking enable further erosion of personal privacy by public, private actors and increased theft and cyber-fraud
- Degradation of the mission of public universities to educate, inspire and equip the new generation – commodification of educational services
- Erosion of the welfare state in Europe
- Loss of trust in traditional financial and political institutions
- New security and authentication protocols protect individuals’ privacy and eradicate risks of (legal or illegal) hacking

References & Sources

- The Francqui international conference on "Europe's Fifth Project" (EUSP) (http://www.srfood.org/en/eu5p)
- The revolution is already happening, (http://www.theecologist.org/blogs_and_comments/commentators/2177708/the_revolution_is_already_happening.html)
Table 1: B. Trust and Reputation

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<th>Title</th>
<th>Description</th>
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</table>
| Description  | Trust can be defined as the belief that people will behave predictably. Institutions are built on trust and are a means to develop trust. The more interdependent people, economic actors, and institutions are becoming the more important trust is for the effective functioning of our societies. Trust is correlated with fairness and responsiveness to societal concerns. Loss of trust can be fuelled by a perceived lack of corporate social responsibility and fair benefit sharing, an increasing gap between the 1% super-rich and the rest, public growth and recovery policies favouring corporate benefits over job creation (e.g. youth unemployment) and responses to the financial crisis not addressing systemic weaknesses and responsibilities for the initiation of the crisis. \[Important risks to trust include:\]  
- Personal information is at risk of becoming less and less private, impacting our ability to prove that we are who we are, and our willingness to engage with others and to trust governments, institutions and private sector actors  
- Rise in counterfeit products across many sectors (pharmaceuticals, manufacturing, luxury goods, media) creates disincentive for investment by legitimate supply-side actors or for purchase by consumers  
- Agri-food is an area where the European system is not fully trusted to produce legislation (such as the EU policy on registration of seeds) to the benefit of the citizens |
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### new values

- Generalised official and semi-official spying and monitoring of individuals’ physical and virtual activities
- Credibility of public educational institutions esp. universities, is compromised by the shift from public service ethos to market-driven objectives
- Gradual dismantling of public social support structures resulting in loss of trust in government
- Apparent loss of trust in social institutions such as marriage and family-building in economically advanced societies
- Emergence of loss of trust in corporate and public institutions regarding the ethical use of technology and the justifications given for this use

### References & Sources

- Transparency International (2012), Corruption Perception Index 2012
### C. Tech Surprise

**Description**

Major technological leaps such as the advent of antibiotics, genetic engineering, the transistor, nuclear power, catalysts, photo-voltaics and the internet have had an immense impact on society and economy. Technological leaps with positive effects are expected in many fields.

The convergence of different technologies and the rising investment in R&D is generating an environment of techno-optimism, with a strong belief that technological breakthroughs are out there to be achieved and all we have to do is develop them through brain-power and R&D investment.

Technology can also have unintended negative surprises. Disaster scenarios include advances in technology getting out of control, leading to catastrophic failure at national, regional or global level, with the possible outcome of machines over-taking the human race on earth, or the evolution of living resources getting out of control, or a major uncontrolled outbreak of a drug-resistant zoonosis.

Are our governance structures and processes sufficiently prepared for dealing with the implications of the waves of technological innovation to come?

**Significance**

The level of complexity of much of tech research and the unknown ramifications of a given domain connecting to others present large-scale risks across the globe. For example, a loss of biodiversity resulting from concentration on a limited number of commercially exploited varieties may restrict mitigation capacities.

**Related Drivers**

Globalisation; Population Changes, Migration & Ageing; Environmental Changes & Degradation; IT, Connectivity & Networks; New & Emerging Technologies

**(Weak signals) Emerging changes and new values**

- Proliferation of observation and killing drones
- Advances in artificial intelligence which can have both positive and negative consequences
- Uncontrolled leaks from nuclear plants such as Fukushima Daiich
- Spread of virus from animals to humans
- Spread of GM food crop into non-GM areas
- Climate change as a result of normal human practices
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<table>
<thead>
<tr>
<th>References &amp; Sources</th>
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<tbody>
<tr>
<td>Johnston, J (MIT Press, 2008), The Allure of Machinic Life: Cybernetics, Artificial Life, and the New AI</td>
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<td>Myers, Courtney Boyd ed. (Forbes, June 2009). The AI Report</td>
</tr>
<tr>
<td>Willacy, M. (MacMillan, 2013), Fukushima</td>
</tr>
</tbody>
</table>

- Discovery of technologies (e.g. catalysts) that would mitigate the effect of CO2 and methane emissions at source
- Quantum computing revolutionises computers
- Technological application of photosynthesis on a large scale for producing energy
### D. Conflict and Insecurity

**Description**

Wars and conflicts appeared to be reducing after the end of the cold war but this trend seems to have stopped. Wars and conflicts may well remain a constant in the coming decades, with likely more civil wars and terrorist activities and certainly a rise in cyber-crime and cyber war. Some see the emergence of unconventional weapons (such as deadly viruses) as a possible escalation in new conflicts, driven by state or non-state actors.

Increasing poverty in Europe fed by on-going economic recession and austerity policies could result in food crisis, survival struggle and social unrest with increasing hostility towards the European integration project. Together with a regain of populism and a return to national rather than European responses, this could ultimately lead to the dissolution of the European Union and the emergence of new divisions and conflicts within Europe.

Major population in-flows, as a result of economic and climate migration, might challenge Europe’s identity in unprecedented ways.

**Significance**

In a highly globalised and connected world, traditional and non-traditional conflicts have the potential to escalate rapidly and to inflict large-scale or even irreversible damage to physical infrastructure, economic exchanges and the fabric of civilisation.

**Related Drivers**

- Globalisation; Population Changes, Migration & Ageing; Environmental Changes & Degradation; IT, Connectivity & Networks; Scarcity of Resources & Energy

**(Weak signals) Emerging changes and new values**

- Civil war in Syria as a war by proxy between Saudi Arabia and Iran, supported by the West and Russia respectively
- Heightened tension between China, Japan, North & South Korea, Taiwan and the Philippines over territorial claims
- Unresolved issue of Turkish occupation of Cyprus
- Continued latent conflict between Israel and Palestine
- Tension between Spain and the UK – Gibraltar
- Economic and climate migration from Africa and other parts of the world caused by catastrophic societal failures in various African states, lack of access to food and/or loss of livelihood and/or subsistence driven by climate change, environmental degradation or socially unsustainable food production systems
- Continued terrorist threats in most major countries (Russia, China, USA)
- Increased political or religious radicalisation of populations fuelled by poverty, hunger and insufficient life
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<tr>
<th>Perspectives</th>
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<tr>
<td>Food or crop failures or water availability pressures (due to global warming?) or natural disasters results in mass migration and/or wars</td>
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<tr>
<td>Proxy local conflicts for the control of materials resources (e.g. Congo) escalate and/or are exported</td>
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<tr>
<td>Economic disparities and desperation or serious political abuse of power lead to serious disturbances or even insurrections</td>
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<tr>
<td>Serious abuse of power (e.g. widespread surveillance or policing) leads to the growth of underground movements</td>
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<tr>
<td>Continuing unwillingness by USA and Russia (and others) to reduce nuclear arsenals lead to a new cold-war instability</td>
<td></td>
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<tr>
<td>Unsatisfied expectations of people in large developing economies (BRICS) due to global economic decline cause upheavals</td>
<td></td>
</tr>
</tbody>
</table>

**References & Sources**

- Booz Allen Hamilton, 2013, *What the astronauts don’t see*
- PwC 2013, *Embedding cyber-security into the energy ecosystem*
### Title
**E. Crisis-Prone Global Economy**

### Description
The 2008 recession has weakened both state and private financial actors as well as damaged the financial well-being of the majority of the population in much of the western world. Given the anaemic recovery experienced in the last two years, successive economic shocks may create a downward spiral of economic depression, protectionism, social unrest and political extremism.

In view of macro-economic developments and of the Federal Reserve monetary policy, the possibility of a US bankruptcy can no longer be totally excluded. This scenario strengthens the argument for a third global currency, as a US bankruptcy or an unravelling of the Eurozone would have major consequences on the global financial system with repercussions on the global economy, international trade, etc. Should such a disruption occur, it would accelerate the shift towards Asian economic leadership.

### Significance
A failure of the Western economies to recover in a sustained way would drag many of the emerging countries – which rely on exports to the West – into stagnation or possibly recession, with social and political impacts.

### Related Drivers
Globalisation; Population Changes and Ageing; IT, Connectivity & Networks

### (Weak signals) Emerging changes and new values
- Rise in unemployment across southern European economies is irreversible leading to long-term economic decline
- Social unrest in European countries such as France, Portugal, Spain and Greece and spreading into other states
- High level of public deficits / debts across 13 of the OECD members
- Continued unwillingness of states to rein-in banks and hedge funds – toxic instruments remain out of control
- Housing or other bubbles cause instabilities and severe boom-bust cycles
- Weak global demand results in a double-dip recession in many countries starting a spiral
- Negative inflation and loss of confidence due to severe austerity measures causes economic collapse (Greece, Spain, ...) with a knock-on effect in other economies
- Globalisation causes knock-on (domino) effect with a positive reinforcement (e.g. slowdown in world economy slows down China and India, reducing demand for German machinery, further slowing down
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| References & Sources | • Federal Reserve Board (Washington, 2013), Aggregate Supply in the United States: Recent Developments and Implications for the Conduct of Monetary Policy
• Capital Economics (2013), European Chart Book
• Elmendorf, D. (2013), Congressional Budget Office report: The Federal Budget: The Deficit is Down But the Fundamental Challenge Remains
• Roberts, P.C. (2012), The Collapsing US Economy and the End of The World

- Concentration of wealth in few hands, reduces overall global productive investment
- Emphasis on (unproductive) financial investments instead of manufacturing or other productive investments, further reduces economic output
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<th>Title</th>
<th>F. Rampant Vulnerability to Natural Disasters</th>
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<tr>
<td>Description</td>
<td>Intense and repeated natural disasters of major scale could overcome our society’s capacity to deal with their consequences. Destructive climate change including rising sea levels could lead to massive destruction of infrastructure and loss of high-quality agricultural land in low-lying coastal areas and require relocation of entire populations.</td>
</tr>
<tr>
<td>Significance</td>
<td>Disasters would have differing effects, from serious flooding of coastal cities and seabords due to earthquakes triggering tsunamis, the grounding of aircraft due to volcanic eruptions, and further marine and other wildlife being destroyed. Whilst more than 90% of natural disaster-related deaths today occur in developing countries, a chain of catastrophic events hitting developed nations could undermine centres of financial and economic systems, deplete research and financial communities and trigger large scale societal unrest coupled with insoluble financial and economic problems. Vulnerability to disasters could generate major threats to food security.</td>
</tr>
<tr>
<td>Related Drivers</td>
<td>Environmental Changes &amp; Degradation; Scarcity of Resources &amp; Energy; Globalisation</td>
</tr>
</tbody>
</table>
| (Weak signals) Emerging changes and new values | - Climatic instabilities due to global warming cause major disasters (rising sea levels, typhoons and hurricanes, flooding, draught etc.)  
  - Yellowstone super-volcano eruption would affect the world  
  - Drought in Chad (June 2012 to February 2013)  
  - Japan northeast earthquake and tsunami of March 2011  
  - Typhoon Haiyan in the Philippines (November 2013)  
  - Haiti earthquake of January 2010  
  - Indian Ocean tsunami of December 2004  
  - Concentration of populations in earthquake or volcanic regions (Indonesia, China, Japan.) magnifies effect of disasters  
  - Conservatism, spiralling costs, misinformation, reduction of medical cover of large segments of the population and distrust (due to perceived big-pharma manipulations, (e.g. huge push for anti-viral buying which were never used) allow pandemics to spread  
  - Spread of diseases after natural disasters magnified by local conflicts |
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References & Sources

- World Vision (Washington, 2013)
- Overseas Development Institute (2003), Economic and Financial Impacts of Natural Disasters: an Assessment of Their Effects and Options for Mitigation
- Guha-Sapir, D. & Santos, I. (Oxford University Press, 2013), The Economic Impacts of Natural Disasters