



## Deliverable 4.5 OBSERVE User Brief 2

<b>Project Name</b>	Observing Emergence OBSERVE
<b>Project No.</b>	665136
<b>Project Type</b>	Coordination and Support Action
<b>Project Duration</b>	1.6.2015-30.5.2017 (24 Months)
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<b>Funded under</b>	Future and Emerging Technologies FET OPEN CSA
<b>Workpackage</b>	WP2 Sensemaking
<b>Deliverable</b>	D4.5 User Brief 2
<b>Submission Date</b>	24.5.2017
<b>Version</b>	1
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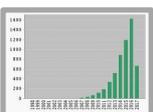
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# 1 Introduction

The Future & Emerging Technologies (FET) programme invests in transformative frontier research and innovation with a high potential impact on technology, to benefit our economy and society. In particular the FET Proactive programme nurtures emerging themes, seeking to establish a critical mass of European researchers in a number of promising exploratory research topics. The aim of OBSERVE is to support the FET unit in identifying topics that fulfil the high aspirations of the FET Proactive funding programme. For this purpose OBSERVE set up systematic screening of a diverse set of sources in 2015.<sup>1</sup> As a result of this process 171 emerging topics<sup>2</sup> of different types.<sup>3</sup> These 171 items were synthesised into 34 clusters which were then integrated with the 59 contributions to the FET Proactive consultation which ran from 10/02/-30/04/2016. The resulting 34 clusters form the “OBSERVE potential hotspots” which are documented in this User Brief. For each cluster we present an assessment of the following three aspects:

	<p>Discourse Diversity: Diversity of underlying sources</p>
	<p>Scientific Publications: Level and dynamics of scientific publications</p>
	<p>Impact Level: Level of potential impact of the emerging development</p>

The assessment is based on the evaluation of the individual emerging topics presented in Deliverable 1.2 OBSERVE Horizons Scanning Report. More detail on these topics including the full list of individual aspects belonging to each emerging hotspot and a detailed explanation of the assessment approach can be found in the OBSERVE Potential Hotspot Report Deliverable 2.1.

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1 Cf. OBSERVE Deliverable 1.3. Methodology Reprot

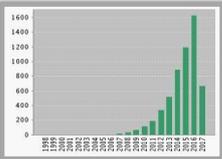
2 Cf. Deliverable 1.2 OBSERVE Horizon Scanning Report

3 The types were Solution Idea, Science and Technology, Challenge/Need, Social Practice, Collaboration.

## 2 The OBSERVE Potential Hotspots

### 2.1 HPC<sup>4</sup> System Disruptions

Current patterns of high performance computing are challenged by a number of disruptive technologies such as Quantum Computing, Non-volatile Memory (NVM) technologies (including spintronics), Photonics, Resistive Computing, Neuromorphic Computing, Quantum Computing, Nanotubes, Graphene and Diamond Transistors<sup>5</sup> but also Biocomputing approaches. Also, computing *practices* may bring about changes. Research could explore radically novel HPC concepts in an integrated vertical approach.

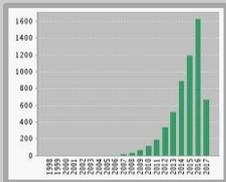
Assessment	
Discourse Diversity 	Medium diversity. Voices stemming mainly from technology quarters with a focus on computer sciences. Nevertheless societal activists and social scientists are looking at societal aspects such as contributions from the DIY movement and novel collaboration patterns.
Scientific Publications 	Very high level of publications with partly very dynamic development
Impact Level 	Strong impacts can be expected in several heavily computing based sectors. Widespread changes could be the consequence especially when HPC system disruptions are combined with other research fields such as bio-manufacturing and societal aspects such as new forms of collaboration and privacy concerns.

<sup>4</sup> High Performance Computing

<sup>5</sup> Cf. <https://ec.europa.eu/futurium/en/content/impact-disruptive-technologies-high-performance-computing-next-decade>

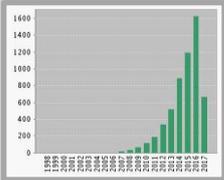
## 2.2 Game Change Enabling Materials

Several of the most dynamic research fronts with highly recognized scientific publications are located in material sciences. While some of these are basic research on synthesis and properties of new materials many focus on specific game changing applications especially in energy storage but also health, robotics, environmental technologies and ICT. In many cases sustainability considerations are an important aspect of the research. Within the cluster the following two areas can be distinguished: Synthesis and analysis of new material types” and “Groundbreaking material application systems”.

Assessment	
<p>Discourse Diversity</p> 	<p>Rather low diversity, mainly driven by material sciences.</p>
<p>Scientific Publications</p> 	<p>High level of scientific activity, in some fields very dynamic development</p>
<p>Impact Level</p> 	<p>High impact to be expected in specific domains such as health and energy.</p>

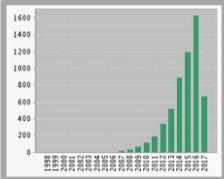
## 2.3 Bacteria Management Strategies

Several of the OBSERVE findings relate to the way humanity deals with bacteria. One of the most prominent aspects is the rise of antibiotic resistance which poses a severe threat to many established practices of today's societies. All the more relevant seem other ways of dealing with bacteria such as antibacterial shields but also better understanding of the role of bacteria for human life (microbiome) and ways to influence bacteria e.g. through genome editing. At the same time bacteria are increasingly being used for processes.

Assessment	
<p>Discourse Diversity</p> 	<p>Within each aspect the diversity of voices in the discourse is rather low. The aspects however stem from very different contexts.</p>
<p>Scientific Publications</p> 	<p>High and partly very high number of publications. Microbiome and CRISPR/CAS extremely dynamic.</p>
<p>Impact Level</p> 	<p>Very high transformative potential with the possibility of widespread impact.</p>

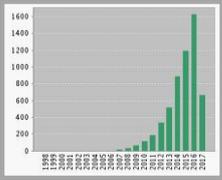
## 2.4 Biomimicry New Frontiers

A rapidly growing number of technologies are inspired by biological functions and solutions. One driver of the new momentum for biomimicry is the advance in simulation and freeform manufacturing (3D printing). Current examples of cutting edge biomimicry innovations include smell-guided-navigation, jellyfish inspired locomotion, insect-inspired robot design (vision and movement) and research into animal system behaviour (e.g. ants) that could help us develop the internet – or even understand how cancer spreads. Furthermore, biological principles and characteristics could be used for better computing. There are already many attempts to emulate biological systems in order to enhance computer chip performance or binary communication processes as well as bio-inspired parallel and neuromorphic computing. In the 2015 Lift China Conference there was a focus in biomimicry as the next generation sustainability concept.

Assessment	
<p>Discourse Diversity</p> 	<p>The cluster rests on a high diversity of voices from a wide range of contexts, disciplines and application domains.</p>
<p>Scientific Publications</p> 	<p>The topics attract a medium number of scientific publications</p>
<p>Impact Level</p> 	<p>Non-disruptive but partly substantial impact in a wide range of domains.</p>

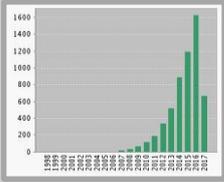
## 2.5 Beyond, Within and Into the Brain

The findings from the OBSERVE screening include several topics related to the brain. On the one hand research on understanding the human brain and brain related innovation are fast advancing. At the same time several societal questions such as the co-evolution of the brain and the digital society and the way to deal with mental illness and are emerging.

Assessment	
<p>Discourse Diversity</p> 	<p>Several isolated specialised discourses but growing interest in overarching meta-questions across disciplines including social sciences.</p>
<p>Scientific Publications</p> 	<p>Very high level of scientific publication activity in the field</p>
<p>Impact Level</p> 	<p>High potential for widespread transformative impact.</p>

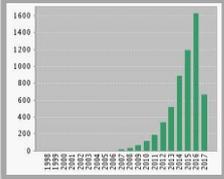
## 2.6 Zero Waste Technologies

Approaches towards a sustainable and circular cradle2cradle economy feature prominently in the debate among scientists, innovators, actors from civil society and policy makers. Establishing fully circular resource flows is however extremely demanding both for design and production. Circular solutions are bound to disrupt established patterns of science and engineering on the one hand and production and consumption on the other.

Assessment	
<p>Discourse Diversity</p> 	<p>Highly diverse discourse across disciplines and contexts.</p>
<p>Scientific Publications</p> 	<p>High and steeply rising level of scientific publication activities.</p>
<p>Impact Level</p> 	<p>Widespread impact across a number of application domains</p>

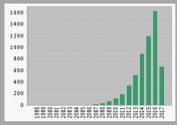
## 2.7 Civilisational Transformation

Some of the OBSERVE screening results reflect on possibly upcoming fundamental transformations of human civilisation including both severe threats such as antimicrobial resistance and decline of global forest and opportunities such as exploration of space and underwater.

Assessment	
<p>Discourse Diversity</p> 	<p>High diversity of voices across domains such as art and science pointing towards essential tipping points for humanity. At the same time several specialised domains with rather homogenous discourse.</p>
<p>Scientific Publications</p> 	<p>Very high in some domains such as antimicrobial resistance but very few scientific paper reflecting on civilisational futures as such.</p>
<p>Impact Level</p> 	<p>Widespread fundamental transformation potential by definition.</p>

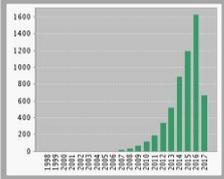
## 2.8 Breathtaking Air Research

Air pollution is a key topic in current futures debates. Monitoring air pollution as well as better understanding its evolution and effects poses substantial challenges to current research. For combating air pollution radical solutions are required.

Assessment	
<p>Discourse Diversity</p> 	<p>Rather specific discourses in several fields</p>
<p>Scientific Publications</p> 	<p>Low to mid level of attention in scientific publications.</p>
<p>Impact Level</p> 	<p>Mostly local impacts but potential for widespread disruptive development.</p>

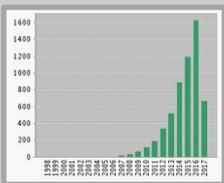
## 2.9 Infrastructures for Communicating in New Dimensions

The OBSERVE screening revealed a diverse set of items related to the way we communicate ranging from highly technical aspects to cultural changes.

Assessment	
<p>Discourse Diversity</p> 	<p>Rather specialised discourses within the topics that are however highly different. Accordingly the total cluster draws together diverse voices.</p>
<p>Scientific Publications</p> 	<p>Mostly low level of publications addressing these rather advanced communication aspects but high attention to the socio-technical shift towards active audience interaction.</p>
<p>Impact Level</p> 	<p>Mostly on local level but potentially disruptive aspects.</p>

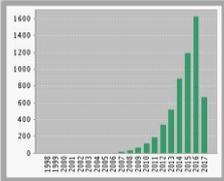
## 2.10 Revolutionary Healthcare Diagnostics

In the field of diagnostics disruptive advances maybe upcoming through a combination of several developments. On the one hand diagnostic technology is able to analyse ever more parameters with ever lighter and cheaper equipment and less time. At the same time more diseases can be detected through analysis of fluids especially blood due to advances in life sciences.

Assessment	
<p>Discourse Diversity</p> 	<p>Rather homogenous discourse in specialist communities from similar contexts.</p>
<p>Scientific Publications</p> 	<p>Very high attention to the general field of lab on chip. Less but quickly rising activity in specific aspects.</p>
<p>Impact Level</p> 	<p>Substantial impact in several specific fields.</p>

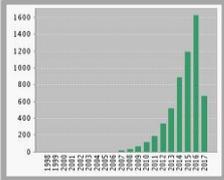
## 2.11 Global Enabling Infrastructures for New Economic Patterns

A number of items captured in the OBSERVE radar reflect on emerging new economic models, the related modes of production and consumption and associated societal and technical transformations.

Assessment	
<p>Discourse Diversity</p> 	<p>Highly diverse voices are arguing around this issue.</p>
<p>Scientific Publications</p> 	<p>The number of publications on the technological aspects such as blockchain and related technologies is rising steeply.</p>
<p>Impact Level</p> 	<p>As this refers to the very deep basics of societal interactions any changes can be expected to have widespread and even fundamental consequences.</p>

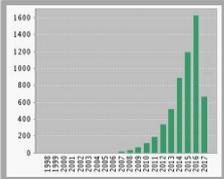
## 2.12 Dormant Effects of Climate Change

The dynamics and effects of climate change are subject to intense research in many disciplines. Researchers from all-over the world point to the increasing likelihood of yet unknown catastrophic events as well as severe health risks and urge acting now. While some aspects are widely researched and discussed, the OBSERVE screening brought up also less explored aspects such as the rise of wildfires, possible emergence of superstorms and effects on soil bacteria.

Assessment	
<p>Discourse Diversity</p> 	<p>A high diversity of sources is pointing in this direction.</p>
<p>Scientific Publications</p> 	<p>The cluster attracts a high number of publications that is still steeply rising.</p>
<p>Impact Level</p> 	<p>Most of the effects of climate change have the potential to substantially transform the framework conditions for human societies</p>

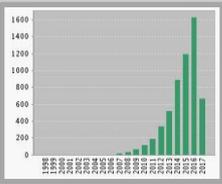
## 2.13 Emergency Preparedness

Several of the findings of the OBSERVE screening point to possible disruptive events that may lead to emergency situations for human societies. At the same time the findings include strategies to deal with and prepare for specific threats and for disruptive change in general.

Assessment	
<p>Discourse Diversity</p> 	<p>The individual threats and possible reactions stem from rather homogeneous sets of sources. The topics and their supporting communities are however very different from each other. Accordingly the cluster combines highly diverse perspectives.</p>
<p>Scientific Publications</p> 	<p>Whereas some threats such as antimicrobial resistance and space weather receive high attention in scientific publications other possible smaller threats such as software bugs are less addressed. Some measures of preparedness such as a pandemics strategy but also new types of collaboration platforms are addressed by quite a few publications.</p>
<p>Impact Level</p> 	<p>Several of the threats have disruptive potential with widespread consequences or even in the case of solar decline fundamental transformation.</p>

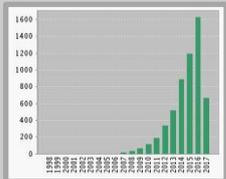
## 2.14 Groundbreaking Food Supply Systems

Feeding the world without transgressing the earth's carrying capacity is one of the key challenges of the future that is also deeply related to other challenges such as water, energy, housing and health. In the near future we have to produce 70% more food than today without harming the environment. Meanwhile, the decrease in variety in plant and animal based food (eg rice/apples) is making food systems more susceptible to pests and diseases. Globally dependency on grain imports is on the rise. Production of meat and fish is rising steeply. At the same time ever more people advocate fundamental changes in human animal relationships. Technical approaches to food production such as smart floating farms, high-tech urban farming (e.g. vertical aquaponic growing system), fully automated and artificial food abound. Another angle is the reduction of food waste. Finally, there is a growing threat from foodborne diseases. Research addressing infection or intoxication caused by pathogenic factors entering into human bodies through food is one of the most dynamic fields in agricultural, plant and animal sciences.

Assessment	
<p>Discourse Diversity</p> 	<p>In total the discourse on novel food solutions is covering diverse technologies and scientific disciplines including social and cultural sciences as well as citizens, artists and poets.</p>
<p>Scientific Publications</p> 	<p>Quite a few scientific publications cover synthetic food and changes in human animal relationship.</p>
<p>Impact Level</p> 	<p>Global food systems are highly interconnected so novel developments are likely to have widespread impact. At the same time there is a need for diverse and tailored local food solutions.</p>

## 2.15 Low Footprint Chemical Processes

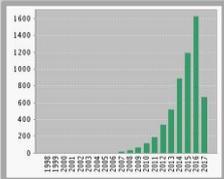
Already in 1998 scientists developed 12 principles of “green chemistry” underpinning more environmentally benign chemical processes with e.g. less waste, higher efficiency and toxicity to human health and the environment. Several findings of the OBSERVE analysis relate to these principles indicating that this domain is still a highly active and future relevant domain for research and innovation with room for disruptive and foundational approaches with substantial sustainability benefit.<sup>6</sup>

Assessment	
<p>Discourse Diversity</p> 	<p>The debate on “green chemistry” remains among relatively few actors</p>
<p>Scientific Publications</p> 	<p>Many scientific publication address aspects of “green chemistry”. Some aspects are even current focus areas with steeply rising attention.</p>
<p>Impact Level</p> 	<p>The expected changes from these process innovations are often not disruptive but rather evolutionary. Nevertheless they carry substantial sustainability benefits such as reduction of energy demand and harmful substances. Therefore if widely applied in large scale processes the transformative potential in terms of ecological footprint is high.</p>

<sup>6</sup> Source: American Chemical Society <http://www.acs.org/content/acs/en/greenchemistry/what-is-green-chemistry/principles/12-principles-of-green-chemistry.html>

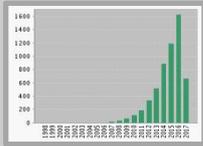
## 2.16 Understanding Beneficial Human Machine Symbiosis

New forms of machine-human-symbiosis emerge on all levels and across types of activities. Aspects range from automation in all spheres of human activities to augmentation of intimate functions within the human body. In spite of frantic research in many of the aspects many argue that there is still little progress in understanding human machine interaction patterns that truly benefit our societies.

Assessment	
<p>Discourse Diversity</p> 	<p>The debate on human machine relationship is led by all types of actors and disciplines.</p>
<p>Scientific Publications</p> 	<p>The field has some topics that are very highly addressed by scientific publications namely modelling the human and automation. But also several other aspects are highly covered. Some more long term concepts (singularity, autonomous production mechanism) but also societal implications are less covered.</p>
<p>Impact Level</p> 	<p>All-together the field has substantial potential to disrupt established socio-technical configurations across a wide range of domains and to initiate widespread and even fundamental transformations.</p>

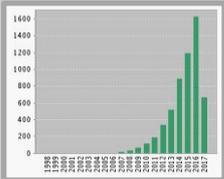
## 2.17 Socio-Technical Internet Futures

The internet will change in a technical and in a social way. Several debates are evolving around its long-term future (OBSERVE H17): Some experts expect that “Intelligence moves to the networked edges”. Smaller and more specific networks may emerge where processing power and intelligence is distributed to “smart-hotspots” that facilitate seamless local interaction between diverse networked people and things (IETF). Today’s infrastructure however limits many of these possibilities. Others speculate about the way the digital and physical world may be interwoven in the future e.g. in a screenless “Internet in things” or a fully ambient user experience. At the same time some observers warn that even today’s expectations on the “Internet of Things” may be inflated and serious infrastructure bottlenecks are looming. Finally, huge efforts are under way to provide remote and mobile internet access points to the internet e.g. through drones or even satellites. On the societal side the rise of non human traffic, trolls, viruses and abusive behaviour is raising concerns that trust in virtual communication is being undermined. Media and artists are increasingly pointing to the dark sides of the internet. Implementation of the “right to be forgotten” in the internet remains controversial. Attempts to create “offline spaces” are on the rise. One FET consultation contribution makes a strong case for designing an Internet of People through putting “the human at the centre of the stage in the design and evaluation of Internet communication systems”.

Assessment	
<p>Discourse Diversity</p> 	<p>Internet futures are discussed by a diverse set of actors from different backgrounds and disciplines from electrical engineering to sociology. Also the topic is present in diverse discourses e.g. in politics, futures studies and the art world.</p>
<p>Scientific Publications</p> 	<p>A high number of publications address different aspects of the topic.</p>
<p>Impact Level</p> 	<p>As the internet has become a backbone for very many sectors of human activity, any innovation is highly likely to have widespread impacts on human societies and economies.</p>

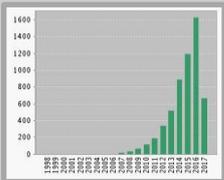
## 2.18 New Ways of Exploiting Functions of Living Organisms

Several of the findings from the OBSERVE screening pointed towards novel ways of using living organisms such as bacteria or plants for fulfilling useful functions.

Assessment	
<p>Discourse Diversity</p> 	<p>The discourse on the individual topics is still mainly among a narrow circle of actors. These communities (e.g. biologists and manufacturing engineers) are however very different from each other.</p>
<p>Scientific Publications</p> 	<p>In the field of the microbiome scientific publications are very high and still steeply rising. Applications of living organism in production processes also receive some attention.</p>
<p>Impact Level</p> 	<p>Both the microbiome and bio-manufacturing imply a potential for widespread impact in their respective domains. Both in health and manufacturing several established paradigms could be questioned by shifting perspectives on the use of living organisms. More specific applications could effect change on a local level.</p>

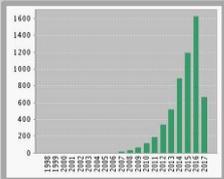
## 2.19 Mixed Realities for Extended Human Sensation

Several sources argue that we are entering the age of multiple realities. Technologies and practices which allow us to experience augmented or virtual reality are extremely prominent in the current discourse: 360 degree videos, advanced vr-gaming, vr-therapy, a real time painting 3D-model translator, vr development tools for animations, paint applications for oculus rift and space experiences. Virtualization and wearable computing devices are expected to combine to create a new wave of social technology. Oculus Rift already allows users to virtually explore real environments from the perspective of a child, and wearable recording devices are beginning to capture the details of everyday life. Developments like the personal headphones which can filter out unwanted noise point to a world where “reality will be in the eye (and ear) of the beholder”. VR and augmented reality topics are one of the most popular areas on Kickstarter. Science fiction novels envisage nano-cells on the skin that simulate an environment for the body that can be felt, heard and seen. Some observers argue that long term visions for “virtual reality societies” are lacking and several challenges remain.

Assessment	
<p>Discourse Diversity</p> 	<p>The discourse is heavily driven by rather small circles of enthusiast (e.g. from gaming communities) on the one hand and futures thinkers including science fiction communities on the other.</p>
<p>Scientific Publications</p> 	<p>A high number of scientific publications is dealing with virtual, augmented and mixed realities.</p>
<p>Impact Level</p> 	<p>As this technology has implications across all sectors and domains of human life the impact of possible breakthroughs could be widespread.</p>

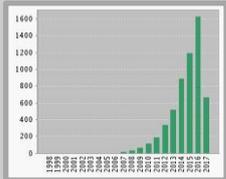
## 2.20 Next Generation Energy Storage (Beyond Lithium)

Research and innovation in energy storage is highly dynamic driven by the rise of decentralised and renewable energy solutions. Important aspects are energy conversion efficiency, speed of storage, cost effectiveness; use of materials with low environmental and social impact. The field includes several potentially disruptive developments that go beyond today's lithium battery based solutions.

Assessment	
<p>Discourse Diversity</p> 	<p>The discourse is highly intense but each topic remains within its community.</p>
<p>Scientific Publications</p> 	<p>New types of batteries are among the most debated topics in the scientific discourse. The number of publications is high and very steeply rising. Also other types of storage solutions receive researchers' attention. The decentralisation of the energy system is a highly dynamic area in terms of publications.</p>
<p>Impact Level</p> 	<p>Solutions to global energy demand are bound to generate widespread impact. Still, tailored local solutions are of paramount importance especially in a decentralised energy framework.</p>

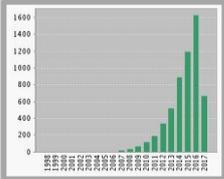
## 2.21 Novel/unconventional Therapeutic Approaches

Several of the OBSERVE findings refer to novel unconventional therapies for different diseases.

Assessment	
<p>Discourse Diversity</p> 	<p>As the approaches are quite specific the discourse remains in relatively homogeneous circle of actors for each topic.</p>
<p>Scientific Publications</p> 	<p>As is often the case in the medical field publication activity is high in most topics. Two less well known perspectives like mirror therapy and designer drugs are highly dynamic.</p>
<p>Impact Level</p> 	<p>From each novel therapy a substantial impact can be expected on the local level of the specific health domain. The perspective of spontaneous regression could span across several domains and impact on a mid range level.</p>

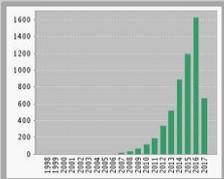
## 2.22 Privacy Providing Systems

Privacy issues are an important element in current future oriented debates especially in the context of the rising use of big data analytics, face recognition and concepts like the internet of things or industry 4.0 on the one hand and concentration of user data in the hands of very few private companies on the other. Two OBSERVE emerging topics highlight the type of disruptive pathways that may be emerging both in terms of privacy threats and privacy solutions:

Assessment	
<p>Discourse Diversity</p> 	<p>The discourse on privacy concerns is highly intense and diverse. Nevertheless the notion of privacy preserving technologies or even systems was brought up only by few sources.</p>
<p>Scientific Publications</p> 	<p>The level of scientific publications is mid to high and rising fast.</p>
<p>Impact Level</p> 	<p>Privacy concerns are reaching across a number of domains. Both threats and solutions are bound to achieve widespread impact.</p>

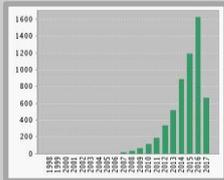
## 2.23 Quantum Research

A number of topics that emerged in the OBSERVE screening deal with quantum research. Aspects cover basic research needs, novel applications but also possible consequences for society.

Assessment	
<p>Discourse Diversity</p> 	<p>The individual aspects are each being discussed in specialists' circles from similar contexts.</p>
<p>Scientific Publications</p> 	<p>The number of scientific publications is on a medium level with grapheme quantum dots considerably higher and dynamically growing.</p>
<p>Impact Level</p> 	<p>As soon as quantum technology moves into applications, widespread impacts such as the disruption of current cryptographic techniques are to be expected.</p>

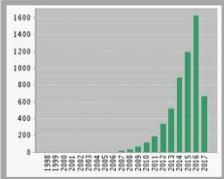
## 2.24 Unlocking Opportunities by Embracing Complexity

Complexity is increasingly recognised both as a challenge and an opportunity in a wide range of science and practice domains. In the very rich and often controversial debate three aspects could be distinguished: Recognising and observing complex processes, decision making in the face of uncertainty, and approaches to embracing and even governing complexity. A central crosscutting aspect is the exploration of human thinking, decision making and behaviour as such.

Assessment	
<p>Discourse Diversity</p> 	<p>The diversity of sources dealing with complexity is extremely high. Voices include not only a wide range of disciplines from physics and informatics to philosophy, sociology and economy but also artists, policy makers and civil society activists.</p>
<p>Scientific Publications</p> 	<p>Complexity, simulation understanding the brain and human behaviour are among the very highest published topics in the whole OBSERVE spectrum. At the same time the field contains topics that are less addressed in scientific papers at the moment such as global decision making systems</p>
<p>Impact Level</p> 	<p>The field is dealing with the very core of human ability to deal with global challenges. Accordingly the impact of advances (or regress) in this is likely to be widespread or even fundamental.</p>

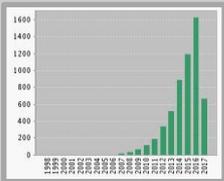
## 2.25 Re-Engineering Life

Several findings of the OBSERVE screening can be grouped under this heading as these approaches are actively attempting to push current boundaries of synthetically modifying or even creating life or else reflecting on the societal implications of such activities.

Assessment	
<p>Discourse Diversity</p> 	<p>The discourse remains within rather specialised circles which however also include ethics and science fiction writers.</p>
<p>Scientific Publications</p> 	<p>CRISPR/CAS is addressed by a high and fast growing number of scientific papers. Approaches to artificial brains and robot reasoning as well as bioprinting also receive a good deal of attention. In bioprinting the development seems highly dynamic.</p>
<p>Impact Level</p> 	<p>The impact of reengineering life can be fundamental in the most extreme cases such as the technological singularity. But also ethnologies like CRISP/CAS and synthetic DNA may effects widespread changes on human lives including both huge opportunities and threats.</p>

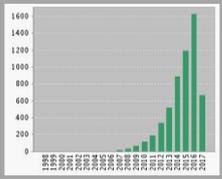
## 2.26 Shifts in Research Practices

The OBSERVE screening revealed debates around changes in research practices. Some are driven by societal demands such as gender equality, transparency, citizen participation and animal rights others stem from shifts in scientific approaches such as increasing use of computational methods.

Assessment	
<p>Discourse Diversity</p> 	<p>Several of the developments changing research practices remain within relatively confined circles. Some aspects however have been brought up by diverse communities: the need for gendering research practices, the emergence of new forms of human animal relationships and the need for distributed collaboration platforms.</p>
<p>Scientific Publications</p> 	<p>Scientists themselves are intensely reflecting on the new approaches especially on bioinformatics, genome wide association studies and simulation approaches. Also other aspects especially the gendering are addressed by quite a few papers with digital humanities steeply rising. The practical aspect of sharing fieldwork failures is less addressed.</p>
<p>Impact Level</p> 	<p>The rise of bioinformatics, genome wide association studies and simulation approaches has the potential for widespread impact on human health and nature of technologies. Changing human animal relationship may also impact across domains e.g. food, culture, medical experiments and agriculture.</p>

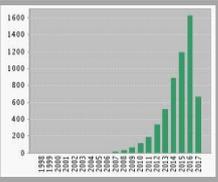
## 2.27 Robotic Frontiers

Throughout the OBSERVE screening period robotics was an extremely dynamic field both in S&T sources and wider public debate. This was driven on the one hand by spectacular breakthroughs most notably in the field of deep learning and autonomous robotics. On the other hand social experiments and art projects such as the hitchhiking robot and the trust inspiring robot (Boxie) as well as popular fiction and movies featuring robots and AI fuelled the robotics discourse. Finally, in the ongoing debates around automation of ever more human activities and industry 4.0 robots form a core element. Aspects related to new forms of interactions between humans and machines are captured under human machine symbiosis.

Assessment	
<p>Discourse Diversity</p> 	<p>These topics are based on a relatively homogenous set of sources from similar contexts.</p>
<p>Scientific Publications</p> 	<p>The number of scientific publications per topic is moderate but especially soft robotics is seeing a steep rise in publications.</p>
<p>Impact Level</p> 	<p>New types of robotics will impact on a mid range level within several diverse fields where robotics are applied ranging from production, disaster recovery to medical applications.</p>

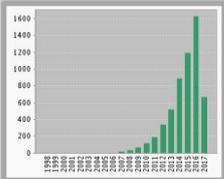
## 2.28 Multi-Signal Sensing Systems

Novel developments in sensing are mainly driven by the use of new materials and new concepts. This includes social innovations such as citizen driven measuring and monitoring initiatives. At the same time urgent requirements such as measurement of ocean acidification are calling for novel solutions.

Assessment	
<p>Discourse Diversity</p> 	<p>Each aspect within this cluster rests on a rather homogeneous set of sources.</p>
<p>Scientific Publications</p> 	<p>Publications on sensor combinations are high and papers on sensors to measure ocean acidification and distributed collaboration platforms are rising fast.</p>
<p>Impact Level</p> 	<p>Whereas each individual sensor development will impact on a rather confined level, widespread changes can be expected through novel combinations of sensors including citizens actively monitoring their environment.</p>

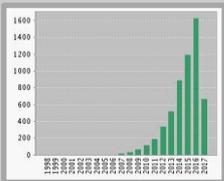
## 2.29 Shifting Understanding of Life and its Boundaries

Our perception of what it means to be human and what characterises other species is shifting. Boundaries between humans and animals on the one hand and humans animals and machines on the other are blurring. Also plants are increasingly viewed in a new perspective e.g. as active communicators. New research methods transform the way we analyse species evolution.

Assessment	
<p>Discourse Diversity</p> 	<p>Except for human animal relationship which is being discussed in different realms of science and society, the aspects within this topic are suggested by a rather homogeneous set of sources.</p>
<p>Scientific Publications</p> 	<p>Scientific publications are on a mid level except for Models for predicting potential distributions of species which is subject of a high number of publications which is still growing fast.</p>
<p>Impact Level</p> 	<p>Radically novel interpretations of life's boundaries such as technological singularity may have fundamental impacts on humanity. But also less disruptive aspects such as a new recognition of plants as living beings or human rights for animals or the establishment of reasoning robots may affect changes that will spread widely or at least affect several domains</p>

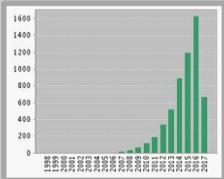
## 2.30 Solar Age

The reinforced search for renewable energy sources forwards the solar technology and solar installations in generally. New designs and materials for solar cells, solar powered devices and monitoring of favourable conditions for solar panel installation (e.g. in space) were key topics in the current debate. Several research aspects in chemistry, material science but also social sciences emerged.

Assessment	
<p>Discourse Diversity</p> 	<p>The solar age is hotly debated in highly diverse communities such as physics, economics, cultural studies and engineering. Also novelists, journalists and policy makers are exploring the implications.</p>
<p>Scientific Publications</p> 	<p>The level of scientific publications is high in the overall field.</p>
<p>Impact Level</p> 	<p>Emergence of the solar age may have widespread impacts on all aspects of human lives including socio-cultural patterns. At the same time a sudden decline of solar activity would fundamentally challenge all life on earth. Break-through in solar technology including materials will affect several sectors.</p>

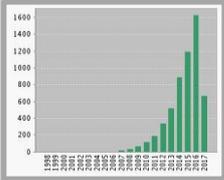
## 2.31 Future Living Spaces

Several emerging topics relate to sustainable living spaces both in urban and rural areas. A particular focus could be on the question of how to dwell in a networked world. As highlighted by one contribution to the FET Proactive consultation there is an urgent need to rethink our approaches to the “built environment” and realise the high potential of cross-disciplinary research on adaptation of spaces to human needs:

Assessment	
<p>Discourse Diversity</p> 	<p>Mobility, housing and urban systems are core functions in human societies and therefore discussed by a high diversity of sources. Naturally however, some of the findings stem from specialist communities.</p>
<p>Scientific Publications</p> 	<p>Apart from a few practice based topics, publication activities in this field are on a high level with especially the topic of drones rising fast in scientific attention.</p>
<p>Impact Level</p> 	<p>In this domain many local solutions may add up to mid level or even widespread changes in the way human living spaces are conceptualised and built.</p>

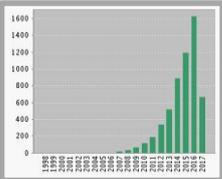
## 2.32 Diverse Unconventional Energy Supply Solutions

Meeting global energy demand in a sustainable manner is one of the most discussed global challenges. In parallel to the mainstream lines of research for new energy technologies and concepts more unconventional approaches are followed by several research and innovation teams. In line with the diversification of energy technologies, innovations in grids and overall system designs are key topics of the debate on energy futures. A particular focus is on the decentralisation of energy supply.

Assessment	
<p>Discourse Diversity</p> 	<p>Energy solutions are of course subject to a wide and highly diverse societal discourse. OBSERVE sources for this topic include also artwork and science fiction.</p>
<p>Scientific Publications</p> 	<p>The cluster is covered by a very high number of scientific publications with two aspects (decentralised energy system and wireless transfer of electricity) strongly on the rise.</p>
<p>Impact Level</p> 	<p>As energy is underpinning all forms of human activities the implications of novel solutions and threats are widespread.</p>

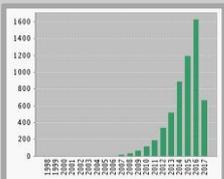
## 2.33 Underwater Operations

Preparing for underwater operations emerges as a highly dynamic domain for research and innovation in a wide range of fields. Key issues are underwater: -gardening, -living, -(mini)robots, -cities, -streetview, -radio (graphene), -chemical plants, -charging, -flight, -volcanoes, -farms, -archaeology, - screening radar, -energy (wave/wind farms) and materials for underwater use. More detail on these topics:

Assessment	
<p>Discourse Diversity</p> 	<p>Underwater solutions were surprisingly well covered within the sources investigated. Findings cover many diverse application fields suggested sources from different contexts.</p>
<p>Scientific Publications</p> 	<p>A very high number of scientific publications is addressing this topic.</p>
<p>Impact Level</p> 	<p>The impact of increasing underwater activity is likely to spread across several domains once the supporting technologies and competences are well developed.</p>

## 2.34 Water Challenge

Water and especially clean water is becoming a scarce resource in ever more areas as climate change threatens water security. We need global strategies to prevent this or deal with. Implementation of existing strategies such as the European Water Framework Directive (WFD) requires suitable tools and methods. Water was one of the most addressed topics in 2015 science related tweets. Topics were water: -generation, -cleaning,-recycling,-pollution, -splitting, -based energy generation, - saving and -quality monitoring as well as measures dealing with droughts. Ways of measuring the quality of oceans, coastal and transitional waters is becoming an important research front in ecology. Another strand of debate is focussing on the future of oceans. Research on the impact of ocean acidification on marine ecosystems is growing fast. Artists such as Maarten Vanden Eynde (plastic reef) point towards the rise of plastic debris in the ocean - a topic that is also much discussed in science publications and media in general. In addition several more specific topics related to ocean futures were raised.

Assessment	
<p>Discourse Diversity</p> 	<p>The sources pointing towards the water challenge are highly diverse and include many sciences, technologies as well as civil society organisations and several artists who reflect on the human impact on oceans.</p>
<p>Scientific Publications</p> 	<p>The number of publications is high and rising fast especially in the field of ocean acidification. Some more specialised fields are also covered by quite a few papers.</p>
<p>Impact Level</p> 	<p>Due to the fundamental role of water for life on earth any developments in the domain can be expected to have widespread impact. Complementary local solutions e.g. for supporting coral reefs are also of key importance.</p>