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Key trends and drivers of change in information and communication technologies and work location

Foresight on new and emerging risks in OSH

Working report

European Agency for Safety and Health at Work

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Main objectives

Information and communication technologies (ICT) and work location have been identified during a consultation exercise across Europe as the topics most likely to have the greatest impact on occupational safety and health (OSH) in the future and how it will be governed. ICT encompasses and enables a wide range of technologies with significant overall implications for the workforce and others affected by work activities. It is expected to fundamentally change where we work, how we work, who will work and how people will perceive work. The European Agency for Safety and Health at Work (EU-OSHA) has, therefore, commissioned a foresight project on ICT and work location.

This foresight project is made up of three work packages. The objective of Work Package 1 is to identify the key trends and drivers of change in ICT and work location. The objective of Work Package 2 is to use the key trends identified during Work Package 1 to develop and test scenarios of the future[1] that will allow policy-makers to consider a range of potential future OSH implications. The objective of Work Package 3 is to disseminate the scenarios developed in Work Package 2 to policy-makers and other interested stakeholders.

This report is the final report on Work Package 1. It describes the process by which the key trends and drivers were identified. The process was broken down into three distinct tasks. The objective of Task 1 was to identify a wide range of relevant trends and drivers through horizon scanning. The objective of Task 2 was to consolidate the trends and drivers through consultation with experts via telephone interviews and a two-stage Delphi-like web survey. There was some indication that participants in the various consultations were influenced by current thinking and media reporting of events that were recent at the time. The second web survey was particularly useful in providing data that helped identify weak signals of longer term trends so that they could also be taken into account. The objective of Task 3 was to select those trends and drivers considered to be the key ones via debate at a mini-workshop of the project team and a small number of invited experts. This report (on the completed Work Package 1) is structured so that each task is described in turn, first the method used and then the results obtained. The results from all three tasks are then discussed overall and conclusions drawn with a view to the implications of the results for Work Package 2.

Main findings

Work Package 1 has provided some preliminary indications of the potential OSH impact of trends and drivers of change in ICT and work location. These include both benefits and risks, which will be explored in greater depth when scenarios of the future are developed in Work Package 2. The primary benefits are removing people from hazardous environments and providing new opportunities for communicating good OSH practice. The risks are mainly psychosocial (e.g. relating to the emotional and cognitive load associated with the 24/7 economy, permanent connectivity, loss of traditional working hierarchies and social interaction at work) and ergonomic (e.g. relating to the increase in the use of mobile devices and new human-machine interfaces). Many comments made during consultations were about work-related stress. There were also comments about bullying and discrimination and whether the new types of jobs and working patterns would provide sufficient employment to provide workers with a living wage.

A major challenge for the application of employment and social security laws, as well as for education and training approaches, relates to a more diverse and less well-defined workforce and to changes introducing more flexible working patterns, which are expected to be brought about by an increase in the prevalence and spread of ICT-enabled technologies (ICT-ETs). This is because ICT-ETs allow work to be done virtually anywhere and at any time, and it is expected to fundamentally change traditional employer-employee relationships.

Although the spread and prevalence of ICT-ETs are currently varied across sectors, ICT is now generally seen to be part of many sectors rather than as a sector of its own, and ICT-ETs are expected to continue to increase across them all, although not necessarily uniformly.

[1] Scenarios are narratives of what alternative futures might look like built up from an assessment of how trends and drivers of changes might influence the present to create each different future.

The spread and prevalence of the application of ICT-ETs are also currently varied across Europe and across different socio-economic groups. There is also evidence that over the next decade there are likely to be significant and accelerating changes in relation to ICT-ETs, which will considerably change the nature of work across Europe and affect most people in some way. This will have the potential to create business opportunities, including stimulating increased productivity and growth in Europe, with the possibility of inequality in the benefits and disadvantages experienced by different workers. It is difficult to predict these changes, so the scenarios will be a valuable tool to help inform EU decision-makers, Member States' governments, trade unions and employers, and to enable them to take appropriate account of changes in ICT-ETs when making decisions to shape the future of OSH towards safer and healthier workplaces.

The key trends and drivers, when considered as a whole, imply that the pace of change of ICT-ETs and how they are exploited in the workplace are likely to be dependent on how demand for and acceptance of ICT-ETs by the public and workers, governance and investment-related decisions support innovations in ICT-ETs (particularly robotics, autonomy and artificial intelligence (AI)), which drive changes in the nature of work and business structures (particularly rapid job changes and turnover).

Taken altogether, the overall conclusion from this work package is that there is a high degree of confidence that the identified key trends and drivers of change are a robust set suitable for generating the scenarios in Work Package 2. The final 17 groups of key trends and drivers have, therefore, fulfilled the primary objective of Work Package 1.

1 Introduction

1.1 Background context

Information and communication technologies (ICT), including ICT-enabled technologies (ICT-ETs) such as robotics and artificial intelligence (AI), are likely to have major impacts on the nature and location of work over the next ten years. Many are talking about a 'fourth industrial revolution'. Moreover, a connected digital single market is one of the European Commission's ten priorities.

The European Agency for Safety and Health at Work (EU-OSHA) has commissioned a two-year foresight project on 'New and emerging occupational safety and health risks associated with information and communication technologies (ICT) and work location by 2025'. This was commissioned in March 2016 and is being delivered by the Health and Safety Laboratory's Foresight Centre, SAMI Consulting Limited and Futurizon Limited.

EU-OSHA is an agency of the European Union (EU) and one of the EU's decentralised bodies. Its role is to contribute to the improvement of workers' safety and health in the EU. As a tripartite organisation, EU-OSHA works closely with governments and with employers' and workers' representatives. In its role as a reference point for occupational safety and health (OSH) information, EU-OSHA commissions, collects, analyses and publishes new scientific research and statistics on OSH risks. It shares good practices and communicates information in a variety of ways to reach workers and workplaces. Through its European Risk Observatory, EU-OSHA looks out for risks that are emerging owing to changes in the workplace, which occur at an increasingly fast pace. EU-OSHA's vision is to be the European centre of excellence for OSH information, promoting a preventive culture to support the goal of making Europe's current and future workplaces safe, healthy and productive.

Current EU strategies (European Commission, 2014) identify the need for a proactive approach in identifying future risks in a continuously changing world of work. Working environments, for example, are continuously changing with the introduction of new technologies, substances and work processes, changes in the structure of the workforce and the labour market, and new forms of employment and work organisation. New work situations bring new opportunities, but they can also create new risks and challenges for workers and employers, which in turn demand political, administrative, technical and regulatory intervention to ensure good standards of safety and health at work are maintained.

Following a successful pilot large-scale foresight project on emerging green jobs and the potential implications for OSH (EU-OSHA, 2013a), EU-OSHA decided to commission further foresight projects. A scoping study was undertaken and this provided recommendations for possible topics to be covered in a future study on new and emerging OSH risks and challenges (EU-OSHA, 2014). This scoping study identified priority key trends for future changes in the nature of work and OSH, which were then ranked according to:

- the strength of evidence found in the literature on possible impact and likelihood;
- priority rankings produced as a result of consultation with stakeholders.

The impact of ICT and work location on OSH received the highest ranking. Opportunities and risks presented by new ICT in the world of work had, a year previously, also been listed by EU-OSHA as a research need (EU-OSHA, 2013b).

The importance of ICT is also recognised in the EU's ten-year jobs and growth strategy (European Commission, 2010), launched in 2010 to create the conditions for smart, sustainable and inclusive growth. This strategy, known as Europe 2020, introduced the Digital Agenda for Europe as one of seven flagship initiatives, recognising the key enabling role that ICT has to play. The Digital Agenda is expected to deliver high levels of employment, productivity and social cohesion by creating a digital single market (European Commission, 2015; Maciejewski and Dimova, 2016) with the aim of:

- improving access for businesses and consumers to digital services and goods throughout Europe;
- creating the best conditions for digital networks to develop and for innovative services to thrive;
- increasing digitisation of European society and the European economy by promoting inter-device compatible standards;
- guaranteeing an open internet in Europe.

Smart growth means strengthening knowledge and innovation. This involves making full use of ICT and ensuring that innovative ideas can be turned into new products and services that stimulate growth, create high-quality jobs and help address European and global societal challenges. Significant EU funds have, therefore, been dedicated to driving research and development in this area.

1.2 Aims and objectives

The overall aim of this foresight project is to provide credible and high-quality information on new and emerging OSH risks posed by changes in ICT-ETs, their use and their impact on the nature of work.

The project aims to meet the needs of policy-makers and researchers to allow them to take timely and effective action. It will help to inform EU decision-makers, Member States' governments, trade unions and employers, so that they can take appropriate account of changes in ICT, its use and its impact on work location when making decisions to shape the future of OSH towards safer and healthier workplaces. It should help them to:

- have a better understanding of longer term developments that could affect workers and how these may result from current policy decisions;
- consider priorities for OSH research and actions that would prevent the occurrence of the identified possible new and emerging risks or minimise any possible negative impact in the future.

These objectives will be achieved through:

- A comprehensive evaluation of the trends and drivers of change in ICT and work location and the potential impact these changes may have on workers' health and safety, taking account of potential new and emerging OSH risks over a ten-year time horizon and beyond.
- The use of a set of scenarios to 2025 (developed during the project) that consider the potential impacts that developments in ICT and changes in work location may have on workers' safety and health.

The process will take account of major developments, in particular the EU digital single market, on workplaces and OSH. It will require multidisciplinary input from policy-makers, OSH experts and experts from other disciplines, to derive future perspectives and to explore the applications and implications of the foresight findings.

The basis of foresight is an understanding that the future can evolve in different directions, which can be shaped by the actions of various stakeholders and decisions taken today. Scenario development will be used as a tool for building visions of possible futures that are clearly relevant to OSH policy. These scenarios can then be used to stimulate discussion about the actions that can be taken today to help avoid future problems or influence what happens in the future. The process encourages the involvement of a wide range of views in order to create different visions of the future and will be adapted to the needs of the target audience.

1.3 Project structure

This foresight project is carried out in three distinct work packages.

The objective of Work Package 1 is to identify key trends and contextual drivers of change that could contribute to creating new and emerging OSH risks associated with ICT and changes in work location. This work package includes the following three tasks:

Task 1 Reviewing existing information to identify trends and drivers of change to 2025 and, where possible, five years beyond. This is done through a combination of horizon-scanning approaches, including a traditional literature review with a focus on recent publications and grey literature.

Task 2 Consolidating the list of trends and drivers of change using the expertise of key people who are aware of trends and drivers of change that may not yet be described in published

material. This is done through semi-structured telephone interviews and a Delphi-like web consultation exercise with a range of experts and key thinkers.

Task 3 Identifying the key trends and drivers, that is, those that are actively involved in shaping the changes in the future. This is done through the use of the impact-uncertainty matrix method during a mini-workshop with the project team and a small number of invited experts.

This report describes the work involved in and findings from Work Package 1.

The objective of Work Package 2 is to develop the scenarios. A set of 'base scenarios' describing possible and plausible visions of the world of work in 2025 will be developed first. These will be shaped by the key trends and drivers of change from Work Package 1. This will be followed by a multidisciplinary workshop involving a representative cross section of participants, including ICT and OSH experts, to explore the future OSH challenges and opportunities associated with ICT and workplace location in each scenario. In a further workshop, with policy-makers, the resulting scenarios will be tested and refined with regard to their use for the development of strategy options addressing the future OSH challenges identified.

The objective of Work Package 3 is to promote the project findings, including the use of the scenarios as a tool to address the future OSH challenges associated with developments in ICT and work location. This will be done through up to six workshops, depending on demand, over a period of 24 months.

1.4 Project scope

The scope of this foresight is new and emerging OSH risks associated with ICT and work location by 2025.

ICT covers a broad spectrum of technologies, ranging from information technology (IT) through social media and all types of audio and video processing and transmission to network-based control and monitoring functions. Over the past three decades, technological 'convergence' has blurred the boundaries between telecommunications, broadcasting and IT. Smartphones, tablets and smart televisions are the clearest examples of this phenomenon. ICT-related changes in the world of work, more so than the technology itself, bring about not only great opportunities but also a number of health and safety risks (Degryse, 2016).

Work location is defined as the type of environment and location where a worker performs their job role. For example:

- A worker can work in one or many locations (e.g. a call centre operator works in the same office each day whereas the area manager for a retail supermarket may travel to different shops).
- A worker and their colleagues may be based in a single physical space or may work with colleagues dispersed across many locations, which could be regional, national, European or international.
- A worker may have multiple jobs at different physical or online locations.

In these examples, ICT enables people to communicate and exchange documents and information without having to be located in the same place. Therefore, work can now be located anywhere where there is an internet connection (Mandl et al., 2015).

This project will focus on the important issues for health and safety in relation to ICT and the nature of work, in particular work location, which could have an impact on OSH within a timeframe up to 2025. It will consider types of technological change at a high level rather than at the detail of specific technologies, for example the development of computing power rather than quantum computing. The focus will also be on the use of ICT rather than the whole lifecycle of ICT; that is, ICT might have an impact on manufacturing processes but the manufacture of ICT itself is not within the scope of the project.

As well as digitisation and ICT, drivers of change on robotics and AI are within scope. The collective term ICT-ETs is used in this report to describe these combined sectors (a full glossary of acronyms and terms used in this report is provided at the end, before the appendices).

Fully defining the scope at the beginning of the project was not possible. Therefore, a 'natural agenda' was used, as this allowed the scope to be kept under review and developed as the project progressed. A natural

agenda allows sub-categories of trends and drivers to be added under the main societal, technological, economic, environmental and political (STEEP) categories as they become apparent. The 'natural agenda' approach also allows the information found during horizon scanning and consultation to be recorded and classified against the sub-categories.

1.5 Purpose of this report

This report introduces the foresight project on ICT and the nature of work, including work location. It records, discusses and draws conclusions from the results of the first work package and explains the methodology used to obtain these results. It provides, in section 3.5, a list of the consolidated trends and drivers of change with a brief description of each. In section 4.5, those trends and drivers considered to be the key ones are listed, with a brief description. These key trends and drivers will be used to define the axes of the scenarios in Work Package 2.

The methodology used for each distinct task undertaken during this first work package is described in turn in sections 2, 3 and 4, along with the results specific to that task. Section 5 discusses the main findings from this first work package. Section 6 gives the conclusions that can be drawn from this work package, which may be subject to change as the foresight project progresses. The research materials (e.g. the interview script and web survey questions) used during this work package and other more detailed information can be found in the various appendices. Further information about and context for each consolidated trend and driver, including initial thoughts about their OSH impact, are given in Appendix J.

2 Review of trends and drivers of change (Task 1)

2.1 Review methodology

In support of the horizon scanning done to review and generate an initial list of trends and drivers of change, a traditional literature search was first conducted by the Information Consultancy Team of the UK Health and Safety Executive (HSE). They were provided with the aims and objectives of the project, a number of search terms (including precise phrases), examples of relevant references, and known trends and drivers. On this basis, they used a search strategy constructed to aim for high precision and wide recall, including formal publications and grey literature, which was limited to the last five years. The terminology was structured to cover all synonyms and spelling variations.

In addition to the traditional literature search, members of the project team carried out further searches of websites of relevant organisations, including but not limited to sources of the types listed below:

- learned and professional journals and societies;
- OSH regulators in a range of countries;
- popular science publications, for example *New Scientist*, *Scientific American*;
- government departments;
- university departments;
- consulting specialists and leading thinkers on ICT-ETs.

These were informed by and supplemented with specialist software that collects, interprets and summarises information daily from over 16,000 sources of futures information. HSL and SAMI also had initial discussions with key experts to inform the scanning — for example what to look for and how to clarify information or obtain unpublished information.

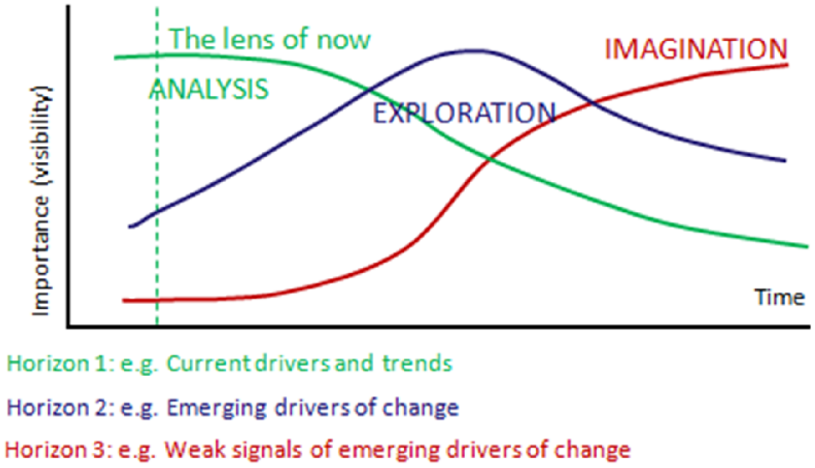
The project team was also kindly provided with useful publications of which the EU-OSHA project oversight team was aware. In addition, existing knowledge gained from earlier relevant horizon-scanning work carried out by HSL and SAMI was reviewed and included, as appropriate.

The information gathered, during all aspects of the horizon scanning, was recorded using a natural agenda, which, as explained in section 1.4, allowed the scope to develop as the scanning progressed. The likely impact on ICT, the nature of work and/or OSH was indicated by scoring each item found as 'high', 'medium'

or 'low'. The likely timescale for the impact to be felt was also recorded against each item as 'soon', 'more than one year but less than five' or 'long'. This reflected the three-horizons model shown in Figure 1.

The information recorded was then subjected to a thematic content analysis in order to select and order the trends and drivers of change based on the STEEP taxonomy, which is commonly used in foresight studies. The selection of the trends and drivers for inclusion in this report was made based on the judgement of the HSL and SAMI teams, taking into account the frequency of occurrence in the search results, the likelihood of change, the likelihood of impact on ICT-ETs and on potential OSH risks and the consequences of those impacts. Material not used in this report has been retained (within the natural agenda, which does not form part of this report) and may, along with material uncovered during the horizon scanning that is ongoing, still be taken into account during the development of the scenarios in the next work package.

Figure 1: The three-horizons model



2.2 Results of review

2.2.1 Trends and drivers to 2025

During the horizon-scanning exercise (Task 1), 92 trends and drivers of change that could impact on ICT-ETs and the associated changes to the nature of work and work location were identified. They were organised according to the STEEP taxonomy. Under each category, except for 'environmental', there were several sub-categories. For example, 'demographics' was a sub-category under 'societal' and 'autonomous systems' was a sub-category under 'technological'. The majority of trends and drivers of change were categorised as societal or technological, both with 29 each. The next largest category was 'economic' with 19, followed by 'political' with 10 and 'environmental' with 5.

There was found to be considerable interaction between many of the trends and drivers, both within the main groups and also across them. For example:

- An ageing workforce, to some extent, drives an increase in chronic health problems, and an increased use of mobile devices increases chronic health problems such as MSDs, while at the same time ICT may provide opportunities for ageing workers and people with chronic diseases to remain in employment.
- Increased connectivity and computer power drive the use of and demand for various flexible working patterns.
- Changes in human resources (HR) management are driven by changes to ways of working.
- The need for new skills is driven by rapid technological change, and the acquisition of new skills may also drive technological change.

- Increased connectivity drives the need for new standards for machine-to-machine communication.

The trends and drivers, as identified during the horizon scanning in Task 1 (i.e. prior to consolidation in Task 2), are summarised in Table 2 and are described in more detail in Appendix A of the published briefing (EU-OSHA, 2016) for people who were consulted in order to consolidate and prioritise the trends and drivers during Task 2. The sources of information used to produce the trends and drivers are listed in section 8.

During the horizon scanning, a few important overarching themes emerged. These were the spread and prevalence of ICT-ETs, the impact of ICT-ETs on economic growth and the impact of ICT-ETs on work. The main findings on these are described in the sub-sections 2.2.3, 2.2.4 and 2.2.5. In addition, the horizon scanning uncovered a range of possible impacts that ICT-ETs could have on OSH, which are described in section 2.2.6.

2.2.2 Trends and drivers beyond 2025

This foresight project focuses on the period to 2025. However, account will also be taken of trends and drivers beyond this period, as some of these will start to influence the nature and location of work by 2025.

It is likely that many, if not most, of the trends and drivers outlined in this report will continue beyond 2025. By 2030, the technological environment may be as follows:

- Seven trillion network devices — all economic activity monitored in close to real time.
- Size of Big Data — in 2016, about 2.5 quintillion bytes of data were generated each day. How much data will be generated per day in 2030?
- Machines will have taken over many cognitive tasks.
- Photonics will deliver nearly 100 % coverage of ultrafast broadband.
- Economics will shift to intangible assets.
- Advanced robotics in business and the home.
- Natural (continuous) speech, voice recognition and translation.
- Fully effective machine vision.

There will also be trends and drivers that are unlikely to have an impact on work by 2025 but could be a major factor in the following decade. One potential example is quantum computing, which may have a major impact on work beyond 2025. It would also be a disruptive technology, as it will be a step-change in processing power and might render current data encryption techniques less effective.

2.2.3 Spread and prevalence of ICT-ETs

ICT is undergoing change at a rapid pace and becoming increasingly ubiquitous, offering access to information at any time, anywhere and on any device (Maciejewski and Dimova, 2016). According to Schwab (2016), technology and society now co-exist. This is driving major changes in how people interact with one another at work and in home life, as well as causing a blurring between the two. It is also bringing about major changes in business models and offerings.

ICT is already very prevalent in manufacturing, retail, finance and entertainment, and is beginning to become prevalent in other sectors, such as healthcare, education, logistics, construction, extraction, office work, the law, clerical work, the arts, sport, public and private transport, and government. Some sectors, such as construction, agro-food, textiles and steel, as well as small and medium-sized enterprises (SMEs), are seen to be lagging behind in their digital transformation (European Commission, 2016a).

The spread and prevalence of ICT differs across European countries. According to the Digital Economy and Society Index (DESI)[2], Denmark, Sweden, Finland and the Netherlands have the most advanced digital economies in the EU. These are followed by Belgium, the United Kingdom and Estonia, with Romania, Bulgaria, Greece and Italy at the bottom of the list (European Commission, 2016b). The extent of the

[2] A composite index that summarises relevant indicators on Europe's digital performance and tracks the evolution of EU Member States in digital competitiveness.

difference is indicated by the fact that, according to the EC, 96 % of Swedes have digital skills, compared with only 50 % of Romanians (Dolphin, 2015).

ICT-ETs are already enabling people to continue to work who might not otherwise have been able to, for example by the use of voice-recognition software. Massive open online courses (MOOCs) are already providing education and training opportunities to many who would not normally have access to them. However, owing to unequal access to the necessary training and education, there is consequently unequal access, among workers, to the benefits of ICT-ETs. There is also the rise of a digital elite due to the opportunities ICT provides to innovative entrepreneurs.

Ever more devices are 'smart', allowing them to communicate with one another (the Internet of Things). In 2015, there were 15 billion devices connected to the internet and 4.1 billion machine-to-machine connections worldwide, and these are expected to grow at an exponential rate (Cisco, 2016).

2.2.4 Impact of ICT-ETs on economic growth

Many trends create business opportunities, including increased productivity and growth. The digital single market has the potential to improve access to information; bring efficiency gains in terms of reduced transaction costs; dematerialise consumption (doing more with less); reduce environmental footprints; and introduce improved business and administrative models (Maciejewski et al., 2014). ICT-ETs allow people to work together across national and geographical boundaries, fostering swifter globalisation (EU-OSHA, 2014). However, technological change is likely to make economic growth increasingly uneven and there is evidence that knowledge work may be increasingly 'offshored' (EU-OSHA, 2015).

More e-commerce generates tangible benefits for consumers, such as rapidly evolving new products, lower prices, more choice and better quality of goods and services, as a result of cross-border trade and easier comparison of offers (Bolognini and Legovini, 2012). Increasing e-commerce is also expected to contribute towards economic growth in the EU, particularly when supported by policy developments such as the European single digital market, not just in retail but also in other sectors (Cardona et al., 2015).

If work becomes increasingly ICT focused, then workers will have skills that are easily transferable from one job to another across different industrial sectors. If jobs are being cut in one industrial sector, this should make it easier for workers to transfer to a different industrial sector, as the skills required will be similar (Hartnett et al., 2015). It also gives those in developing or emerging economies better access to work (Leopold, Ratcheva and Zahidi, 2016).

Generation Z, also known as digital natives, who are about to enter the workplace, tend to be more entrepreneurial than the previous generation. As digital technology supports this type of behaviour (Robert Half Inc., 2015), this could stimulate economic growth.

2.2.5 Impact of ICT-ETs on work

ICT has had a steadily growing impact on work since personal computers first entered the workplace around 1970. Early word processing and data analysis supported existing jobs. As computer power increased and the internet expanded, there were more fundamental changes, including many existing jobs being replaced by ICT and new jobs being created. AI, which attempts to replicate the process of human thinking, is likely to increase these impacts and is now able to analyse unstructured data, understand increasingly complex questions, and provide answers and solutions. One milestone was reached when, in 1997, IBM's 'Deep Blue' became the first computer to beat the reigning world chess champion, Garry Kasparov. Now AI is being increasingly used to assist workers, such as for medical diagnosis (IBM, 2016), or to replace workers, such as financial analysts and personal assistants (in the sense of secretaries) (Biewald, 2015).

These trends have depended on increasing communication bandwidth and mobile technologies that now enable access to anything, anywhere, at any time. People no longer need to be located in the same place to communicate and exchange documents and information. ICT enables people to work flexibly, while travelling or from home. Their workplace can be anywhere, as growing wireless internet connectivity and mobile hotspots allow people to carry out their duties away from the office, for example in public spaces

such as railway stations, cafes and shops. Public spaces, homes and temporary office environments are used as work environments by an increasing group of workers, so-called e-nomads.

ICT-ETs impact on a great many aspects of modern life, including work. They have contributed to the virtualisation of the working environment and the development of the 24/7 global economy, which require the flexible organisation of work tasks, high flexibility in working hours and quasi- continuous availability for work activities. People can now communicate with each other using a variety of means — for example mobile phones, emails, Skype and social media. Generation Z, who are generally familiar with and heavy users of ICT and social media, are about to enter the workplace and are likely to bring their communication preferences with them.

There has been a similar trend with robotics. Since the 1960s, fixed 'industrial robots' have been capable of performing manufacturing tasks with minimal human assistance. Over the last few years, collaborative robots or 'cobots,' which work collaboratively with humans (rather than being separated from them by physical barriers), have started to have an impact on work. Fully autonomous robots have also started to find work applications.

These trends are merging and accelerating and the term 'second machine age' (Massachusetts Institute of Technology Center for Digital Business, 2013) is being used to describe a change that is likened to a 'fourth industrial revolution'; the first being the advent of steam power, the second that of electricity and the third that of personal computers. However, this 'fourth industrial revolution', unlike the previous industrial revolutions, is evolving at an exponential rather than a linear pace (Schwab, 2016). It is characterised by exponential improvement in computing power; the digital nature of core technologies; collaborative innovation to create even more value; and machines taking over cognitive tasks that were previously done by humans. Schwab (2016) states that we are 'at the beginning of a revolution that is fundamentally changing the way we live, work, and relate to one another' and that in 'its scale, scope and complexity' it is 'unlike anything humankind has experienced before'. He makes the case that it is already leading to 'profound shifts across all industries, marked by the emergence of new business models, the disruption of incumbents and the reshaping of production, consumption, transportation and delivery systems'. He describes the changes as 'historic in terms of their size, speed and scope and so profound that, from the perspective of human history, there has never been a time of greater promise or potential peril', calling on all stakeholders to work together to better understand the emerging trends.

ICT-ETs affect the types of jobs available, how we work, where we work and organisational structures. Increasing numbers of workers spend their days in front of a computer screen or a mobile ICT device. ICT-ETs also enable new business models and offerings. Therefore, ICT is no longer seen as a specific separate sector but rather as a provider of essential services for all sectors of our economy and society. This has led to a blurring of the boundaries between different industries and sectors (Department for Occupational Safety and Health Finland, 2015). Even in jobs where a physical presence is required, such as manufacturing, computer control, increased automation and the use of robots are changing the nature of work. The number of warehouse robots used by Amazon, for example, has grown from 1,400 to 30,000 in less than two years (Frey et al., 2016).

2.2.6 Impact of ICT-ETs on OSH

The use of ICT and ICT-ETs has the potential to provide certain OSH benefits, primarily by removing people from hazardous environments. Workers can also be protected by automating dangerous tasks; for example, drones can be used to avoid working at height or in other hazardous environments. ICT-ETs can also have a positive effect for workers in terms of improved quality of work by automating mundane jobs. There are also new opportunities for communicating good OSH practice, providing good-quality training, and keeping and sharing records about OSH exposures. Flexible working patterns, enabled by ICT, can contribute to well-being at work and allow people to juggle their work and private life. The use of ICT-ETs enables people to communicate and exchange documents and information without having to be located in the same place. This reduces the need for people to travel in order to attend meetings in person, which reduces exposure to the risks associated with travel.

However, the use of ICT-ETs and the demands they can place on workers can lead to the emergence of new hazards (Mandl et al., 2015). There is the risk of placing too much trust in the infallibility of technology

(SUVA, 2011). Increasing automation can lead to a lack of sufficient understanding of the underlying process that can lead to an accident due to someone doing something inappropriate or not knowing what to do when something goes wrong. Workers are more likely to make mistakes due to a poorly designed human-machine interface. It is not known how humans will react to the continuous high cognitive load of increasingly complex human-machine interfaces (EU-OSHA, 2013a). However, it is reported that cognitive and/or mental overload can lead to not only a higher likelihood of mistakes but also ill health due to stress (EU-OSHA, 2009).

A more globally connected world of business facilitated by ICT could in some cases also lead to changing patterns of business activities and changes in associated risks.

Flexible working patterns and the 24/7 economy can lead to workers facing increasing workloads and task complexity, excessive working hours, feelings of isolation (as personal relations are replaced by virtual contacts) and finding it increasingly difficult to achieve a good work-life balance as a result not only of work pressure but also of the 'fear of missing out'. Consequently, there is the danger that workers can suffer from stress and 'burnout'. It is likely to be hard to assess OSH risks consistently and regularly for mobile or remote workers. They may also suffer from a lack of OSH monitoring and poorer access to OSH services. A virtual workforce could find it difficult to know that OSH information and services relevant to them exist and it could also be very difficult for OSH regulators to influence such a workforce (Department for Occupational Safety and Health Finland, 2015).

The increasing expectation that workers will remain connected and doing computer-based work while out of the office, including while travelling, could lead to the use of mobile devices that are less ergonomic than desktop devices and could, therefore, cause musculoskeletal disorders (MSDs) (Department for Occupational Safety and Health Finland, 2015).

The use of computers and automated systems at work leads to fixed body postures and physical inactivity at work. Physical inactivity is associated with increased health risks such as coronary heart disease, overweight or obese, certain types of cancers and psychological disorders such as depression and anxiety.

The use of ICT-ET innovations such as advanced interfaces, automation, ambient intelligence or the greater use of robotics may potentially bring about increasing health and safety risks associated with exposure to electromagnetic fields (EMFs) (SCENIHR, 2015).

3 Consolidation of trends and drivers of change (Task 2)

3.1 Consolidation methodology — interviews

A purposive sample of 19 experts, drawn from a range of organisations, including three members of EU-OSHA's Prevention and Research Advisory Group, was interviewed by telephone. The experts, who are listed in Appendix A, were selected from countries across Europe, with expertise in a variety of different fields to provide coverage of all STEEP categories. The data forthcoming as the interviews progressed were monitored to allow the expertise of subsequent interviewees to be targeted to match any gaps that became apparent.

Before the interviews, the selected experts were sent a one-page description of the project and a consultee briefing (EU-OSHA, 2016) that listed and described the trends and drivers of change in ICT and work location identified in Task 1 of this work package.

The primary objective of the interviews was to consolidate the list of trends and drivers of change identified during the earlier Task 1 desk-based horizon scanning (EU-OSHA, 2016). A further objective was to obtain initial views on which trends and drivers will have the greatest impact on ICT and the nature of work, including work location, up to 2025. Initial views on new and emerging OSH risks associated with the drivers were also sought, but the scope for this varied between interviewees and this will be the specific objective of Work Package 2, Task 2.

A semi-structured approach was taken to the interviews based on the 'Seven Questions' technique, which was developed by SAMI Consulting and is now widely used in scenario-building exercises (Ringland, 2006). The interview script, which includes the seven questions used, can be found in Appendix B.

Interviewees were advised on how the information gathered would be used, that interviews were voluntary, and that they could choose not to answer particular questions and change their mind about participating at any point including during the interview. Moreover, they were assured that their comments would be unattributable, that is, it would not be possible to link comments to any individual. They were, therefore, invited to give their own views and not necessarily those of their organisation. The questions were designed to be 'open', to give interviewees the freedom to develop ideas and the interviewer the freedom to explore them in more depth, where appropriate, in a relaxed, conversational manner.

The interviews were not audio recorded; instead, the interviewer took notes on which they conducted a thematic analysis in order to code the comments made by the interviewed experts against the same STEEP-based 'natural agenda' as used for the horizon-scanning data. If comments did not fit against any of the codes they were coded as '??' to allow the identification of possible additional trends and drivers. The comments were then reviewed to code them in terms of whether they mentioned something relating to any of the trends and drivers identified during the horizon scanning in Task 1 (EU-OSHA, 2016). The coded comments were then analysed' to identify which trends and drivers were referenced most in the comments by the interviewees. The purpose was to see to what extent the interviews had a similar coverage of trends and drivers to the horizon scanning done in Task 1 of this work package. The results are described and explained in section 3.3.

3.2 Consolidation methodology — Delphi-like web surveys

3.2.1 First web survey — methodology

The first web survey, hosted on the HSE Communities internet site, was undertaken in parallel with the interviews. It was designed to complement the data from the interviews and provide quantitative data about the relative importance of the trends and drivers in each of the STEEP categories.

The web survey was promoted via EU-OSHA's OSHmail, SAMI Consulting Limited's newsletter, Twitter, LinkedIn and direct emails to personal contacts of the project team.

Respondents were provided with some background information that explained that completing the survey was voluntary, that they did not have to answer any questions if they did not want to and that they could withdraw at any time. They were also told where they could find further information, including the briefing that was sent to interviewees. They were first asked background questions about their nationality, the country in which they worked, the job they did, the sector they worked in, and their expertise in ICT and OSH. They were then presented with the complete list of drivers and trends for each category in turn and asked whether there were any trends or drivers that they disagreed with or any that had been missed in that category. They were then asked to choose those they thought were the most important in each category using drop-down menus that listed all the trends and drivers in that category. They could choose up to 3 out of the 29 societal trends and drivers, 3 out of the 29 technological trends and drivers, 3 out of the 19 economic trends and drivers, 1 out of the 5 environmental trends and drivers, and 2 out of the 10 political trends and drivers. The trends and drivers were simply numbered from 1 to 92 to help the user to identify them when making their choices and comments. Respondents were also asked what they would want to discuss if they could spend some time with someone who knew the future and were given an opportunity to make any further comments.

The choices made were used to rank the trends and drivers in each STEEP category in order of importance according to the number of choices made for each one. The open questions were thematically analysed against the list of trends and drivers to:

- identify which ones respondents disagreed with and how often;
- identify possible additional trends and drivers;
- obtain important supporting information on those trends and drivers that had already been identified during the earlier horizon scanning.

The complete question set can be found in Appendix D, and the results are described and explained in section 3.4.1.

3.2.2 Second (follow-up) web survey — methodology

A second, follow-up, web survey was conducted in order to give respondents to the first web survey a chance to comment on the ranking by importance of the trends and drivers according to the choices that had been made by other respondents. This was set up as a follow-up survey hosted by the same HSE web community. It was emailed directly to those who had provided contact details in the first web survey to indicate an interest in participating in later parts of the project. It was also promoted as a comment on the LinkedIn messages originally used to promote the first web survey.

Respondents were given some brief information about the purpose of the survey, were again told that completing the survey was voluntary etc. and were provided with links to further information, including the consultee briefing report (EU-OSHA, 2016). They were first asked whether they had responded to the previous web survey and, if not, asked the same background questions as respondents to the previous one. They were then presented with the charts, given in section 3.2.1, showing how the trends and drivers had been ranked in each of the STEEP categories and asked the following open questions:

- To what extent do you agree with those trends and drivers that are scored as MOST important? Please explain.
- To what extent do you agree with those trends and drivers that are scored as LEAST important? Please explain.
- Do you have any further comments on trends and drivers in each category?

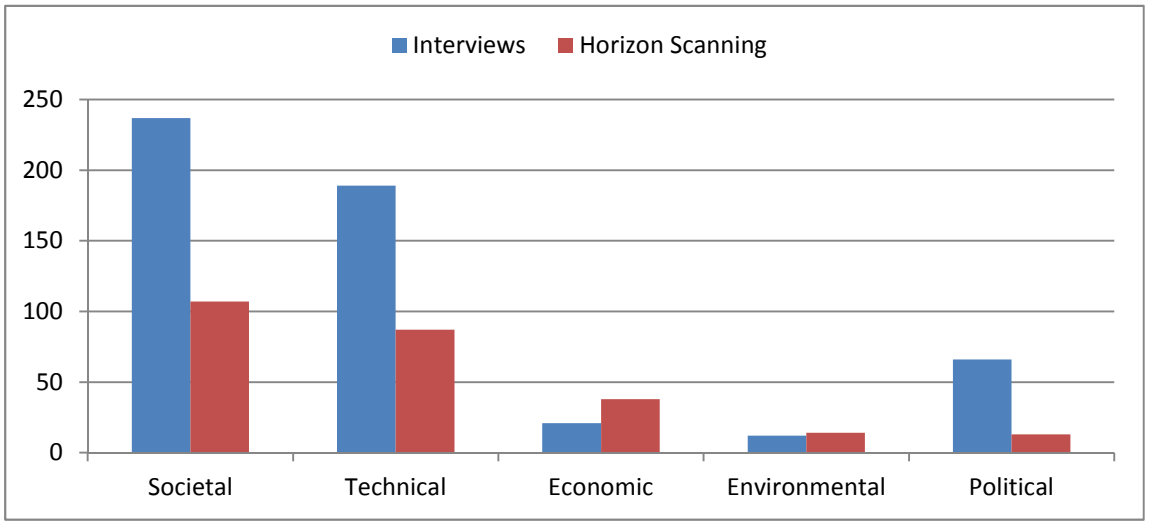
Respondents were also given an opportunity at the end of the survey to provide any final comments. The results are described and explained in section 3.4.2.

3.3 Results of consolidation — interviews

Over the period from 31 May to 29 July 2016, interviews with 19 relevant experts from 9 EU countries, including central, southern, northern and eastern countries, were conducted. Three of the experts worked in European institutions. The interviewees' expertise ranged from a high-level knowledge of ICT as a whole to deep specialisms such as robotics or OSH. All but one expert had ICT-related technological expertise. Societal and political expertise were also well represented (five each), with two interviewees having economic expertise and one having environmental expertise. The duration of the interviews ranged from about 45 to about 90 minutes. By monitoring the data forthcoming as the interviews progressed, it was possible to target the expertise of subsequent interviewees to match any gaps that became apparent. Sufficient information was, therefore, obtained once 19 experts had been interviewed.

Although only the first question asked specifically about trends and drivers, the responses to other questions included useful comments about trends and drivers as well as providing other pertinent information. Taken together, there were almost 300 comments, compared with 237 items found during the horizon scanning. These comments gave good coverage of the trends and drivers identified during the horizon scanning, with only one of the environmental, two of the technological, two of the political, five of the societal and nine of the economic trends and drivers not being mentioned in some way. Overall, 80 % of all trends and drivers identified in the horizon scanning were mentioned in the interviews. The majority of comments, like the items found in the horizon scanning, related to societal and technological trends and drivers, as shown in Figure 2. There were fewer comments relating to economic and environmental trends and drivers than items found during the horizon scanning relating to these categories. There were twice as many comments relating to political trends and drivers as items found during the horizon scanning relating to these categories, which was very useful.

Figure 2: Number of interviewee comments relating to each STEEP category



The numbers of comments made by interviewees that referenced something relating to each of the trends or drivers of change originally identified during the horizon scanning in Task 1 are shown in Figures C1 to C5 in Appendix C, along with the number of comments that provided new information. Note that in some cases interviewees talked at the level of the heading of a sub-category rather than at the more detailed level of an individual trend or driver. For example, they might have talked about advanced interfaces rather than a specific type of interface.

Comments made by the interviewees, particularly in the societal and technological categories, supplemented the horizon scanning. For example, some of the comments added new examples, opportunities or implications that could be incorporated into existing drivers. These have been added to the detailed descriptions of the drivers and trends developed during the horizon scanning (EU-OSHA, 2016), which can be found, as modified, in Appendix J. Other comments led to the modification of several drivers to incorporate additional themes that came out of interviewees' comments (shown in Table G1 in Appendix G); a few comments identified two additional trends or drivers (shown in Table G2 in Appendix G).

One issue that was raised a number of times by interviewees was work-related stress. This had already been included as a potential implication of many of the trends and drivers[3] identified during the horizon scanning, in the societal, technological, economic and political categories (as shown in Appendix J). The implications will depend on the combination of the trends and drivers in each scenario, so it will be important to take work-related stress into account during the development of the scenarios. The key comments on stress were:

> *'The ability of workers to control their work is key to reducing stress. We should be dealing with the causes of stress, balancing job demands with capabilities, preventing stress rather than coping with it. Working in a world where you don't understand or control what you are doing, under ever-intensifying conditions causes stress — you are just executing instructions as they come, with very little control over your time. This means building meaningful work patterns and avoiding workers being seen as cogs in the machine.'*

The last comment could suggest that there is an opportunity to improve OSH under drivers S2.1 — 'Flexible working' and S2.5 — 'Changes to HR management'.

> *'If all routine work is automated, what remains is only the hard part. Need the right balance of work quality.'*

This suggests that opportunities to improve OSH should be considered under Driver T2.1 — 'Automation' and T2.2 — 'Robotics and cobots'.

[3] S1.6, S2.1 to S2.5, S4.2, S4.5 and S5.2, T1.5 to T1.7, T2.2, T2.4, T3.1, T3.2, T5.1, T5.4, Ec4.3 and P2.1.

'Everything becomes too much. Competing messages, too much noise.'

'There has been a tendency to explain work-related stress by personal factors — amount of sleep or exercise — and encourage people to cope with stress this way. Rather, we should be dealing with the causes of stress, balancing job demands with capabilities — prevent rather than cope. Stress comes not from work problems themselves but from the ability to solve problems, i.e. control.'

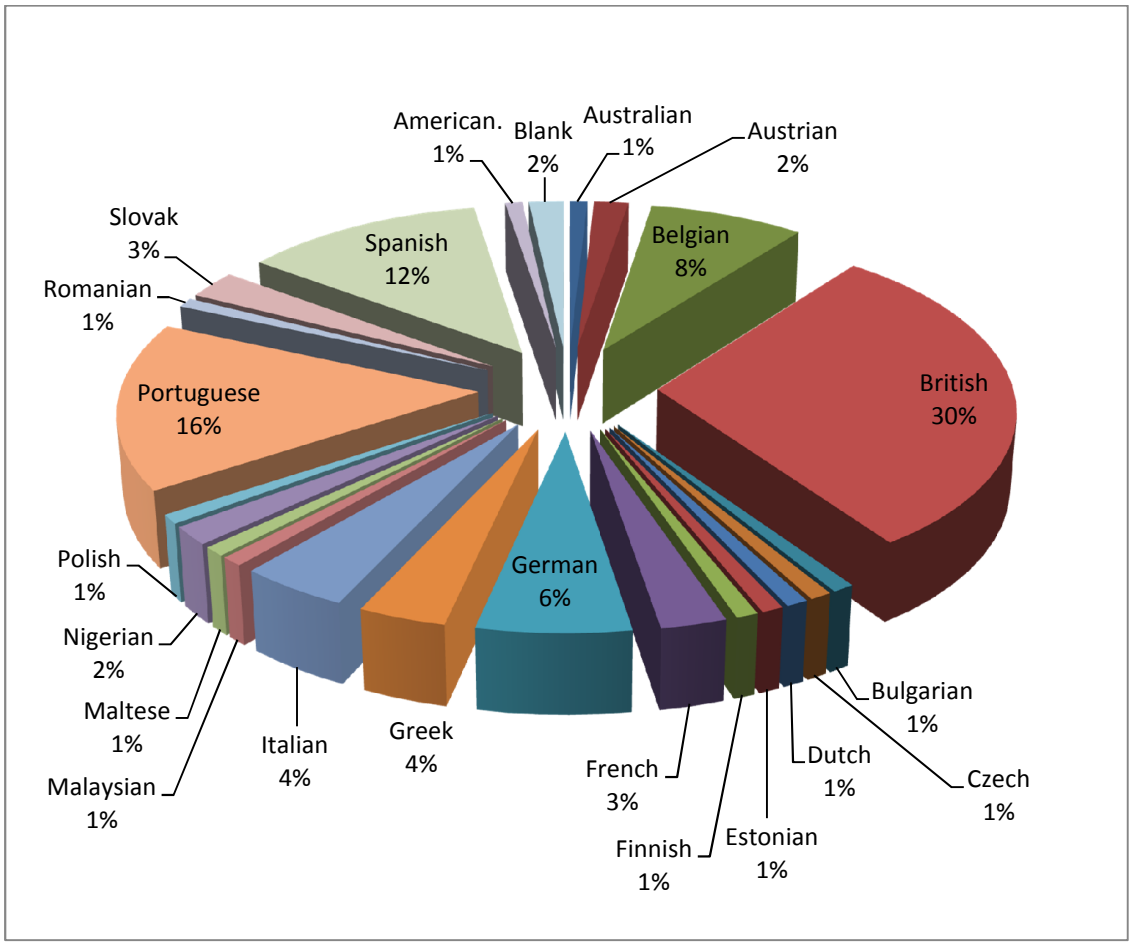
3.4 Results of consolidation — Delphi-like web surveys

3.4.1 First web survey — results

The first web survey was launched on 13 June 2016 and remained open for a little over four weeks, closing on 6 July. During this period, there were 140 downloads of the consultee briefing and 114 useable responses from the 22 different countries shown in Figure 3. Twelve respondents stated that they worked across Europe, ten that they worked internationally (one said that this was only occasionally), eight worked in a different country from their nationality and two worked in the country of their nationality and also in an adjacent country.

The quantity and quality of responses to the open questions was very good, although not all respondents voted on the trends and drivers, and some of those who did made only one or two choices when they had the opportunity to make up to three. A total of 30 people, from a variety of countries (Belgium, Bulgaria, the Czech Republic, Germany, Italy, Portugal, Spain, the United Kingdom, Malaysia and Nigeria), provided a contact email address as an expression of willingness to participate in later stages of the project and/or interest in receiving the results of the web survey.

Figure 3: Self-declared nationality of respondents to web survey (*n* = 114)



From a review of job titles and sectors provided by respondents, it was apparent that many had an OSH-related job. There were also several respondents with policy roles, working in management, research, academia, foresight and government (policy and research). There were a few working in law, publishing, ICT and health. There were two frontline workers (one working as a machine operator and one who had retired owing to injury). Finally, there was one respondent working in quality, one working in sales and one working for a trade union. A breakdown of the responses to the questions about expertise in OSH and ICT is shown in Figures 4 and 5 respectively.

Figure 4: Self-declared expertise in OSH of web survey respondents (*n* = 110)

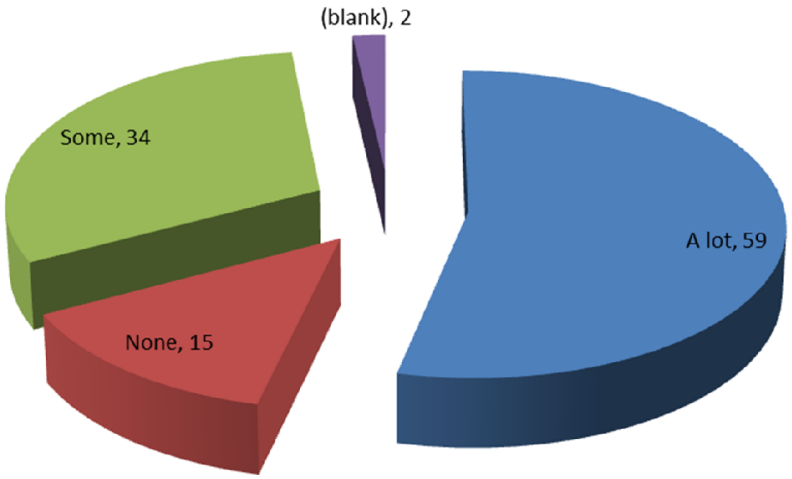
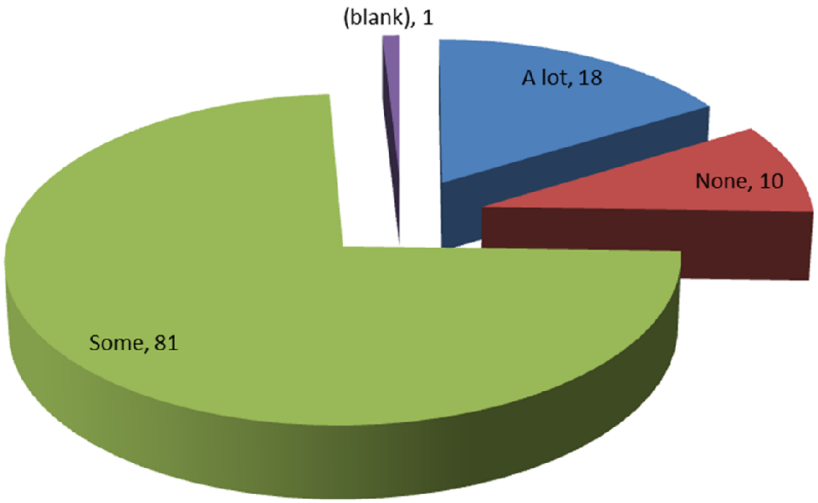


Figure 5: Self-declared relevant ICT expertise of web survey respondents (*n* = 110)



For half or more of the trends and drivers in each category one or more of the respondents indicated that they disagreed with them. However, the total number of people that disagreed with any specific trend or driver was very small, in most cases just one or two. In the case of 11 drivers there were as many as 3 respondents who disagreed; 2 drivers had 4 respondents disagreeing; and only 1 driver had 6 respondents disagreeing. There was some evidence that some respondents misunderstood the word ‘disagree’ to mean

'feel concerned or unhappy about'; for example, one comment was '*I don't like the concentration on personnel information in a few companies.'* However, in many cases it was clear that respondents understood the question, for example '*Health problems — really? Does the data show increase in prevalence of long-term disorders? People are healthier and living longer than ever.'* The list of all the trends and drivers that respondents disagreed with, along with the comments made, can be found in Appendix H.

Responses to the question, for each of the STEEP categories, about whether any trends or drivers were missing did not lead to the identification of new trends or drivers. Responses did, however, generate useful additional details on the trends and drivers. These have been added to the detailed descriptions of the drivers and trends already identified during the horizon scanning (EU-OSHA, 2016). These descriptions can be found, as modified, in Appendix J. Other responses led to the modification of some drivers to incorporate additional themes (see Table G3 in Appendix G). The changes made to the original list of trends and drivers as a result of these types of comments are reflected in the consolidated list of trends and drivers given in Table 1, section 3.5, and in the more detailed descriptions provided in Appendix J. The comments that led to the changes are shown in Appendix G.

The ranking of the trends and drivers (identified during Task 1) as a result of the choices respondents made when asked which trends and drivers they thought were the most important, under each STEEP category, are shown in Figures E1 to E5 in Appendix E.

For the societal category (Figure E1):

- The trend/driver ranked as most important, 'Increased inequality and polarisation', was the only one that obtained over 20 votes. Interestingly, this was also the driver that had the most people stating that they disagreed with it. However, this was only six respondents.
- The trend/driver that got the most votes, 'Increased inequality and polarisation', was respondents' most popular third choice, whereas the one that got the second most votes, 'Ageing workforce', was respondents' most popular first choice.
- The top ten trends/drivers had more first choices than those ranked lower.
- Twelve trends/drivers got more than five votes.
- The trend/driver ranked as least important, 'Crowd working', was one person's first choice, and the second least important, 'Fluid co-working spaces', one person's second choice.
- Six of the sixty-six respondents did not select second choices, but they all selected a third.
- There were no votes for 'Rise of the green lobby'.

For the technological category (Figure E2):

- The trend/driver ranked as most important, 'Cybersecurity', was respondents' most popular first choice. However, this may be due to participants being influenced by the extent of media coverage at the time about terrorism and state-sponsored hacking of computer systems.
- The top ten trends/drivers had more first choices than those ranked lower.
- Sixteen trends/drivers got more than five votes.
- The trend/driver ranked as least important, 'Bionics', was one person's first choice.
- Two of the fifty-eight respondents did not select a third choice.
- There were no votes for 'Wearables'.

For the economic category (Figure E3):

- The trend/driver ranked as most important, 'Rising globalisation', was the only one that got more than 20 votes.
- First choices were quite distributed, that is, not focused on the top ten.
- Thirteen trends/drivers got more than five votes.
- The trend/driver ranked as least important, 'Reshoring', was one person's first choice.
- One of the fifty-seven respondents did not select a second choice and two did not select a third choice.
- There were no drivers or trends that were not chosen.

For the environmental category (Figure E4):

- The trend/driver ranked as most important, 'Disease', was the only one that got more than 20 votes.
- Four trends/drivers got more than five votes.
- There were no drivers or trends that were not chosen.

For the political category (Figure E5):

- The trend/driver ranked as most important, 'Increasing geopolitical volatility', was respondents' most popular second choice; the second most important, 'Terrorism and war', was respondents' most popular first choice.
- First choices were quite distributed, that is, not focused on the top ten.
- The trends/drivers ranked as least important, 'e-government', and second least important, 'Blurring of borders', were two respondents' first choices.
- Eight trends/drivers got more than five votes.
- One of the fifty-seven respondents did not select a second choice.
- There were no drivers or trends that were not chosen.

The open 'Oracle' question, at the end of the web survey, in particular, provided useful information about the issues that respondents were concerned about. One recurring theme was work-related stress, which had already been included as a potential implication of quite a lot of the trends and drivers identified during the horizon scanning (see Appendix J). The implications will depend on the combination of the trends and drivers in each scenario, so it will be important to take work-related stress into account during the development of the scenarios in Work Package 2. The key comments on stress were:

'Effect of excessive ICT use on workers? Information overload? Technostress.'

'Information overload, always-on; society creating a blurring of the work-life balance.'

'Increased work intensification and restructuring as a constant.'

'The link between technology and mental health.'

'Implications of ICT and changes of work location in lifestyle and work-life balance.'

Another issue that was mentioned in several responses was discrimination and bullying. This was not captured during the horizon scanning, and the cyber-bullying trend/driver has been modified to incorporate the comments. However, owing to the recurring theme, it was felt, in the judgement of the project team, to be sufficiently important to note the following comments in this report:

'Segregation and alienation — due to the influence of the media and negative attitudes surrounding immigration, many workplaces now find that they have an internal segregation of workers or workplace discrimination — i.e. foreign workers are not socialised with, or are discriminated against.'

The above was also included as an implication of Driver S1.3 — 'Increasing migration into the EU'.

'Rise in xenophobia — right wing attitudes and racism.'

'How business is going to tackle diversity.'

'Increasing cultural, ethical and religious diversity, and potential conflicts.'

'The emerging of digital discrimination as a form of work related violence and the specific impact on vulnerable groups and technology related sectors.'

'How defamation, dignity, working time, discrimination, data protection will interact with occupational safety and health.'

'How to stop bullying, harassment at work, sexual and moral.'

Another issue that was mentioned in several responses related to the existence of sufficient employment in the future. Again, this was highlighted as a potential implication of several of the trends and drivers identified during the horizon scanning (see Appendix J), but it was also considered, in the judgement of the project team, important to note the following comments in this report:

'Will future employment be able to provide most workers/employees with sustainable incomes, i.e. can you make a living and generate savings with a 40 hours/week job?'

'Where are the jobs for the less intellectually gifted people?'

'The most critical issue that I would see is massive unemployment due to exponential rise of robots and AI.'

3.4.2 Second (follow-up) web survey — results

The follow-up web survey was launched on 27 July 2016 and remained open for almost 4 weeks, closing on 23 August. During this period, 34 people opened the survey but only 11 responded to the questions; the rest left all fields blank. All of these 11 stated that they had responded to the previous web survey. There was some evidence that people were first looking at the questions and then going back to answer them. However, it also appeared that some people were simply curious or only wanted to look at the results from the first web survey. The follow-up survey was much shorter and easier to complete than the first web survey, so complexity is unlikely to be the reason why so few did so. The timing of the survey, during the long summer vacation, and the fact that it was not promoted via OSHmail are likely to have contributed to the low response rate. Another reason may have been that people did not feel qualified to comment. This reason is supported by the fact that not all respondents commented on all the categories and by one respondent's comment to the effect that they thought people might have not understood the concepts in the survey.

The extent of agreement of each respondent with the ranking obtained from the first web survey, along with the comments made, was useful in prioritising the trends and drivers, as described in section 4.2.2. The comments were particularly useful for understanding any differences between the number of references by interviewees that related to each of the trends and drivers and the rankings of them as a result of the first web survey. The comments made for each of the STEEP categories are recorded in Tables F1 to F5 in Appendix F.

Societal trends and drivers

Two respondents totally agreed with those societal trends and drivers that had been scored as most important, with a further seven mainly agreeing. The number of respondents who commented that certain trends or drivers should have scored higher was:

- three — 'Generational differences' (S1.4);
- two — 'Lifelong learning' (S3.4);
- one — 'More women in the workforce' (S1.5);
- one — 'Shift working' (S2.6).

Two respondents commented that 'Gaps in ICT skills' (S3.2) should have scored lower and one commented that they thought that 'Gaps in ICT skills' (S3.2) and 'Ageing workforce' (S1.2) were correlated.

Three respondents totally agreed with those societal trends and drivers that had been scored as least important and a further one agreed to some extent. One person also commented that, while they agreed with those that were scored as least important, they were nevertheless still important. The number of respondents who disagreed with certain trends and drivers being scored low was:

- two — 'Future of collective action' (S4.4);
- two — 'De-skilling' (S3.8);
- two — 'Crowd-working' (S2.3);
- one — 'Changes in HR management' (S2.5);
- one — 'Access to online education' (S3.7).

One respondent also commented that 'public perception and attitudes seems a relevant area', which could refer to S4.1 or S4.3.

Only three respondents made further comments. The first pointed out that there has been research and analysis on crowd-working. The second commented on the potential for there to be serious societal rifts in

the future caused by inequality, the cost of the ageing population and other pressures such as large-scale migration. The third commented that the green lobby was 'now taken into government policy but having a mega-effect'. These comments could indicate that the respondent felt that the following drivers should have scored high or higher: 'Crowd-working' (S2.3), 'Inequality and polarisation' (S1.7) and 'Ageing workforce' (S1.2).

Technological trends and drivers

Three respondents agreed with those technological trends and drivers that had been scored as most important, with two more mainly agreeing. The number of respondents who commented that certain trends or drivers should have scored higher was:

- two — 'Wearables' (T3.2);
- two — 'Social media' (T5.1);
- one — 'Technological advances' (T1.1);
- one — '5G' (T5.4);
- one — 'Bionics' (T2.3);
- one — 'Need for new standards' (T1.4), with one more commenting that it was interesting to see this being considered so important, which could be either just an observation or a comment to the effect that it should have been scored lower.

One respondent commented that 'Cyber-security' (T5.7) should have been scored lower.

Only one respondent specifically stated that they agreed with those technological trends and drivers scored as least important, with another simply saying they were surprised by the scoring and implying that they disagreed with the two that were scored highest, 'Cyber-security' (T5.7) and AI (T2.4). The number of respondents that disagreed with certain trends and drivers being scored low was:

- three — 'Autonomous vehicles' (T2.7);
- two — 'Augmented reality' (T4.1);
- two — 'Wearables' (T3.2);
- one — 'Additive manufacturing' (T2.6);
- one — 'Bionics' (T2.3), although the respondent commented that this was likely to be over a longer timescale;
- one — '5G' (5.4);
- one — 'Social media' (T5.1).

In response to the invitation to make further comments, one respondent commented on 'Robotics' (T2.2) becoming increasingly important and another that, while '3D printing' (T2.6) had been around for a while, owing to the expiry of various patents it may become much more important in the future.

Economic trends and drivers

Two respondents agreed with those economic trends and drivers that had been scored as most important, with two more mainly or broadly agreeing. The number of respondents who commented that certain trends or drivers should have scored higher was:

- one — 'Knowledge economy' (Ec3.6);
- one — 'Off-shoring' (Ec1.2).

There was a comment about debt being an increasing problem, which could relate to 'EU growth since financial crash of 2008' (Ec2.1) and also have an impact on 'Availability of investment funding' (Ec2.4), 'Inequality and polarisation' (S1.7) and 'Investment in education and employment initiatives' (P1.4). There was also a comment about individuals making decisions being the most important factor in the economy, which could relate to 'Knowledge economy' (Ec3.6), 'Alternative distribution chains' (Ec3.3), 'Rise of the entrepreneur' (Ec3.4) and 'Peer-to-peer finance' Ec4.2), and possibly also 'Sharing economy' (Ec4.1).

Two respondents agreed with those economic trends and drivers that had been scored as least important, with two more mainly agreeing. One respondent commented that 'BRIC countries' (EC1.5, changed during

consolidation to 'Emerging economies') should have been scored higher but another commented that they thought it was right that this had been scored low. One respondent said that 'Reshoring' (Ec1.3) may be more important than its score indicated but pointed out that it would not necessarily create jobs, owing to increasing use of automation and robotics.

In response to the invitation to make further comments, one respondent mentioned the importance of the supply chain, which relates to 'Alternative distribution chains' (Ec3.3), one mentioned the importance of 'Reshoring' (Ec1.3) and one commented that Brexit should be included. Another respondent commented that BRIC was not a useful term, and this has been removed from the consolidated list.

Environmental trends and drivers

One respondent agreed with those environmental trends and drivers that had been scored as most important, with one 'fundamentally' disagreeing. The number of respondents who commented that certain trends or drivers should have scored higher was:

- three — 'Energy' (Ev2), with one saying that it had probably been scored low as people think that the problems with energy security will be solved, which they probably agreed with;
- three — 'Climate change' (Ev1).

Two commented that 'Disease' (Ev5) should have been scored lower, but one commented that it was right that it had been scored high.

The same respondent who agreed with those environmental trends and drivers scored as most important also agreed with those scored as least important. The same respondent who fundamentally disagreed with those scored as most important also fundamentally disagreed with those scored as least important. Three respondents simply reiterated the comments they had made when asked the extent of their agreement with those trends and drivers scored as most important, with a further respondent commenting that 'Energy' (Ev2) is a major driver and another that 'Limited supply of rare earth metals' (Ev3) should be the least important.

In response to the invitation to make further comments, one respondent commented that air pollution was an increasingly important issue and another that food and access to water should perhaps have been included. This has been reflected in the fact that Ev3 has been modified from 'Limited supply of rare earth metals' to 'Limited availability of natural resources' in the consolidated list of trends and drivers.

Political trends and drivers

Four respondents agreed with those political trends and drivers that had been scored as most important, with two more mainly or broadly agreeing. The number of respondents who commented that certain trends or drivers should have scored higher was:

- one — 'European digital single market' (P1.1);
- one — 'Regulation of new working patterns' (P1.6);
- one — 'Governance of the internet' (P1.7), 'Governance of ICT' in the consolidated list;
- one — 'e-government' (P1.2).

Two respondents commented that 'Geopolitical volatility' (P2.2) and 'Terrorism and war' (P2.1) should be lower, with one of these pointing out that these two might be high as a result of a high level of media reporting about them at the time.

Two respondents agreed with those political trends and drivers that had been scored as most important, with one more mainly or broadly agreeing and one commenting that they were all very correlated. Two respondents commented that 'e-government' (P1.2) should have been scored higher and one that 'Blurring of borders' (P2.3) and 'Migration' (P1.5) were 'going to be major political issues'.

In the further comments, one respondent commented that neo-liberal political theory may be on the decline, with an acceptance of the need for more intervention. Another respondent commented that the growth of transnational blocs on the one hand and the growth of localism and nationalism on the other needed to be included.

3.5 Consolidated list of trends and drivers

The trends and drivers of change as consolidated following the consultation with experts and the web survey are shown in Table 1, and, with more detail, in Table J1 in Appendix J. Both of these tables take account of the modifications summarised in the tables in Appendix G and the additional information provided by responses to the interviews and first web survey. Table J1 also includes initial findings on the potential impact of each driver and trend on ICT-ETs, work location and OSH. Some of the findings are based on information found in the list of sources given below. This has been supplemented by the project team's knowledge of recent and ongoing, as yet unpublished, research in the field of OSH, analysis and interpretation (based on their combined experience of foresight studies and OSH research). This information is only a preliminary indication for the purposes of supporting the discussions on the trends and drivers with experts. The OSH impact of the drivers will be explored in more depth in the next work package. The sources of information used to produce the initial list of trends and drivers are given in section 8, rather than cited within the table, to make the table easier for consultees to use.

Table 1: Summary of trends and drivers, as revised as a result of the interviews and web survey

Category: SOCIETAL	
Sub-category: Demographics and Characteristics of the Workforce	
S1.1	**Population changes** — while the global population is rising, the EU population is slightly falling and there is also a shortage of active workforce.
S1.2	**Ageing workforce** — while the average age in the EU is increasing, there are variations across the EU.
S1.3	**Increasing migration into the EU** — caused by large differences in standard of living between countries and refugees from conflict, facilitated by mobile devices providing ease of access to information about different countries and travel options.
S1.4	**Generational differences** — the increasing length of working life means more generations in the workplace, from the 'digital natives' to those who have been working for some time, who are coming close to retirement age or who have already retired, with very differing attitudes to hierarchical organisational structures, sharing information online and ease of using ICT at work.
S1.5	**More women in the workforce** — who tend to prefer and/or be more willing to have flexible working patterns.
S1.6	**Increasing number of workers with chronic and complex health problems** — (including MSDs, cancers, mental health disorders, etc.) and the need for more inclusive and adapted workplaces, increased incentives at policy level and awareness-raising initiatives.
S1.7	**Increased inequality and polarisation** — owing to the benefits from technological innovation not being spread evenly across socio-economic groups, with low-paid unskilled workers at one end of the spectrum and a 'digital elite' at the other. This could be to such an extent that it causes social unrest and increased migration.

Sub-category: Employment Patterns	
S2.1	**Flexible working patterns** — includes growth in demand (from organisations and/or individuals) for flexible working hours; part-time (voluntary and involuntary); zero-hours contracts (or on-demand workers); shorter-term temporary contracts; self-employment; home working; mobile and shift working.
S2.2	**Virtual workplaces** — working online anywhere and any time, such that location is irrelevant.
S2.3	**Crowd-working** — whereby an online platform is used to enable organisations or individuals to access an indefinite and unknown group of other organisations or individuals to provide specific services or products in exchange for payment.
S2.4	**Fluid co-working spaces** — shared physical workspaces where different individuals work who are generally not employed by the same organisation.
S2.5	**Changes to HR management** — these range from surveillance and monitoring of workers' location, activity and productivity by data profiling to flatter organisational structures where workers are supervised less, have more autonomy and are judged by innovation as well as output, rather than just time spent at work.
S2.6	**Shift working — merged with S2.1, 'Flexible working patterns'.**
Sub-category: Skills	
S3.1	**Increases in basic ICT skills** — while there is variation between generations and countries, the proportion of people with basic ICT skills and the level of these is increasing and is expected to further increase.
S3.2	**Gaps in ICT skills** — owing to growth in demand, the pace of change leading to skills becoming quickly outdated, and declining numbers of people studying science, technology, engineering and/or mathematics.
S3.3	**Increasing need for advanced reasoning skills** including problem solving, judgement under uncertainty, creativity, and interpersonal and emotional intelligence.
S3.4	**Lifelong learning** — owing to the high pace of change in the workplace and extended working lives, people are increasingly likely to need retraining several times during their careers.
S3.5	**Job mortgages** — owing to changing working patterns, workers are likely to have to take increasing responsibility for their own training. This may include workers borrowing money to cover the cost of training against their future potential earnings.
S3.6	**Quickening pace of knowledge transfer** — driven by instantaneous global communication and increasing networking.
S3.7	**Access to online education** — commercial, internal and massive open online courses (MOOCs).
S3.8	**De-skilling**, for example due to increased use of automation.

Sub-category: Public Attitudes	
S4.1	**Attitudes to and awareness of risk (all relevant stakeholders)** — will affect the take-up of new technology and working patterns.
S4.2	**Attitudes to online privacy** — people may be concerned about privacy and security of data, but they may still be willing to share data online because of the convenience this brings with it.
S4.3	**Public attitude to (acceptance of and demand for) ICT developments and ethics** — major new developments will be dependent on the acceptability of and demand for the technology, which is dependent on whether it is seen as a threat to people's preferred way of life/social model or ethics.
S4.4	**The future of collective action** — there is diversity in union density across the EU; however, the general trend is a fall in trade union membership. New online platforms for collective action may spring up to replace trade unions.
S4.5	**Discrimination, violence and bullying** — facilitated by the rise in the use of ICT-ETs and social networking at work.
S4.6	**Decarbonisation, green targets and sustainability** — there is an increasing awareness of and campaigning for green issues and sustainability, which could affect how and where people work.
Sub-category: Urban Environment	
S5.1	**Smart cities** — where ICT is used to manage a city's assets, such as schools, hospitals, transport infrastructure, water, and energy supply, such that they are integrated with community services.
S5.2	**Increasing urbanisation** — individuals are increasingly moving to cities to work, and this trend is set to continue over the next decade.
Category: TECHNOLOGICAL	
Sub-category: Pace of Change	
T1.1	**Technological advances in ICT** — technology is advancing on many fronts, which allows advances in ICT.
T1.2	**Advances in computing power and speed** — computers are becoming ever more powerful, reducing in cost and getting smaller. Continuing advances, however, are expected to need new types of transistor.
T1.3	**Technical challenges for ICT** — such as limited electromagnetic spectrum, availability of energy, need for new types of transistor, and battery charge life may constrain continued developments and growth in the use of ICT.
T1.4	**Need for new standards** — to enable more and more different technological devices to 'talk' to each other. A lack of common standards may limit ICT advances.

T1.5	**Internet of things** — the potential for vast numbers of cheap sensors taking measurements opens up a wealth of possibilities for machine-to-machine (M2M) communication and pervasive sensors, especially when combined with Big Data analytics and machine learning.
T1.6	**Big Data** — is a combination of three trends: increasing rate of data generation; improving data storage; and advancing data analysis.
T1.7	**User-centred design (new)** — if technology is designed with the end-user's needs and OSH in mind, then it is more likely to be widely and successfully adopted.
Sub-category: Autonomous Systems	
T2.1	**Automation** — any activity that is characterised by being repetitive, routine, structured and rules-based is likely to be automated over coming decades.
T2.2	**Robotics and collaborative robots** — robots are becoming capable of carrying out ever more intricate tasks and of operating alongside people. They are also increasingly autonomous and self-learning.
T2.3	**Bionics** — robotic-based technologies can be used to augment human activities and strength or to overcome disabilities, for example through exoskeletons. Such devices are becoming increasingly available, affordable and capable.
T2.4	**Artificial intelligence (AI)** — is typified by machines making rules-based decisions autonomously from an operator; increasingly, machines are able to learn from experience.
T2.5	**Industry 4.0** — the 'Internet of Things' and machine-to-machine (M2M) communication are enabling an emerging trend of 'lights out' manufacturing (manufacturing without human involvement).
T2.6	**Additive manufacturing (AM)** — also called rapid manufacturing or 3D printing, is an automated process that produces three-dimensional objects directly from digital models by the successive addition of materials.
T2.7	**Autonomous vehicles (AVs)** — are increasingly being used on private land and being tested on public highways worldwide. Interim features, such as self-parking and collision avoidance assistance, are already being deployed.
T2.8	**Drones** — their use for work purposes is expanding rapidly and this is expected to continue in the future.
Sub-category: Miniaturisation and Portability	
T3.1	**Growth in mobile ICT devices** — as a result of increasing computing and battery performance, coinciding with miniaturisation and faster and more widespread access to WiFi, 5G and beyond.
T3.2	**Wearables** — miniaturisation has happened to such an extent that devices, rather than being carried in bags or pockets, can increasingly be worn or incorporated into clothing.

Sub-category: Advanced Human-Machine Interfaces	
T4.1	**Augmented reality (AR)** — provides contextual visual information alongside real-world views.
T4.2	**Virtual reality (VR)** — the use of computer technology to create a simulated, immersive 3D environment that can be interacted with. VR systems primarily use head-mounted displays (HMDs) but can also use a display screen.
T4.3	**Immersive communication** — uses ICT technologies to create natural experiences and interactions with remote people and locations.
T4.4	**Interfacing via other human senses** — such as via gesture control, eye tracking technology, speech recognition and instantaneous translation; these technologies are becoming increasingly capable and ubiquitous.
T4.5	**Direct** computer-to-brain **interfaces (invasive and non-invasive)** — computer-to-brain interfaces including those aiming to produce perceptions by stimulating the brain are being researched and developed.
Sub-category: ICT Services and Infrastructure	
T5.1	**Social media** — is increasingly popular as a tool to enable individuals and businesses to communicate, network and collaborate across the world.
T5.2	**Cloud computing** — allows workers across the world to work together by sharing data and information. By 2020, the amount of data going through the cloud globally is projected to be over double the amount in 2013.
T5.3	**Open intellectual property movement** — concern has been expressed that unless Europe moves to an open data model, the digital economy is unlikely to progress.
T5.4	**Advanced networking, internet and WiFi protocols** — advances in networking that will enable a far more secure, transparent, flexible, verifiable, instantaneous and functional network.
T5.5	**Merged with T5.4. 'Advanced networking, internet and WiFi protocols'**
T5.6	**Deleted owing to duplication with S3.7 'Access to online education'**
T5.7	**Cybersecurity** — attacks on companies' assets and services through their IT are becoming increasingly sophisticated and difficult to detect.
T5.8	**Advanced materials** — a range of novel materials may improve the performance of many current ICT technologies and work environments.
Category: ECONOMIC	
Sub-category: Globalisation	
Ec1.1	**Changes in levels of globalisation** — have shown fairly steady growth from 1980 and expectations are that they will continue apace; however, there are also some indications that the trend may slow down or even reverse.

Ec1.2	**Offshoring** — is currently used by the majority of large companies for manufacturing. While there is uncertainty about whether this will continue to rise, there is expected to be a rise in the offshoring of knowledge-based work facilitated by the digital economy and crowd-working.
Ec1.3	**Reshoring** — there is some evidence that ICT advances such as 3D printing and automation, along with concerns about quality and rising costs, are beginning to create a trend towards companies moving their manufacturing closer to home.
Ec1.4	**Increasingly well-educated Asian workforce** — it is projected that by 2030 India and China will provide at least 60 % of workers in science, technology, engineering and mathematics.
Ec1.5	**Emerging economies** — eastern European countries and those outside of the EU are growing faster and becoming important emerging markets.
Sub-category: Macro-economic Environment	
Ec2.1	**EU growth since the financial crash of 2008** — assumptions of steady growth across Europe have been challenged and public debt limits are putting constraints on investment.
Ec2.2	**The economic value of data** — in order to create a data-enabled economy, there is a need for data to be valued economically and included on balance sheets. Data sets could be traded through a regulated framework.
Ec2.3	**Insurance** — if perfect data become available, there is the possibility that low-risk businesses may no longer feel it necessary to purchase insurance.
Ec2.4	**Availability of investment funding (new)** — innovation and developments in and the diffusion and use of ICT are reliant on the availability of investment funds, either from private companies or governments.
Sub-category: Changing Industry Structure	
Ec3.1	**Micro-enterprises and small and medium-sized enterprises** — globally, there is an ongoing rise in the number of micro-enterprises and small and medium-sized enterprises (SMEs).
Ec3.2	**Effect of ICT on other sectors** — advances in ICT will continue to have an impact on the amount and types of jobs accessible and the skills needed in different sectors.
Ec3.3	**Alternative distribution chains** — increasing sales direct to consumers, between peers and consumer to consumer.
Ec3.4	**Rise of the entrepreneur** — digital technologies help the entrepreneur of the future, as they allow low start-up costs and fast scale-up.
Ec3.5	**Increase in e-commerce** — driven by the increasing pervasiveness of mobile internet devices; has resulted in an ongoing decline in retail jobs but more logistics jobs.
Ec3.6	**Increasing knowledge economy** — is an ongoing trend towards trading in knowledge and information rather than physical artefacts.
Ec3.7	**Rise in the service sector** — an ongoing increase is being experienced in Europe.

Ec3.8	**Sub-contracting** — the growth of self-employment and increased globalisation tends to drive a growth in sub-contracting.
Sub-category: New Business Models	
Ec4.1	**Sharing economy** — the sharing rather than owning of assets such as cars appears to appeal to the 'millennial' generation, so can be expected to grow further and may extend more into sharing of work equipment, along the lines of a modern equivalent of agricultural cooperatives.
Ec4.2	**Peer-to-peer finance** — with crowd-sourced funding, becoming a more prevalent source of funding for innovators to get their inventions to market.
Ec4.3	**Servitisation** — where the service provider, rather than the consumer, owns the product that provides a service.
Category: ENVIRONMENTAL	
Ev1	**Climate change** — analysis suggests that global warming will be more substantial (at 2.7°C) and occur sooner (by 2036) than previously predicted.
Ev2	**Energy** — ICT currently uses a significant amount of the world's electricity, generating approximately 2 % of global carbon dioxide emissions. ICT development may be affected by energy shortages that could occur if innovations in energy generation are not sufficient.
Ev3	**Limited availability of natural resources** — ICT-ET manufacture uses various natural resources. Rare earth metals, for example, are essential in many ICT-based technologies. There are increasingly lower levels worldwide and restricted exports.
Ev4	**Green economy** — waste materials from the manufacture and eventual disposal of ICT equipment could become increasingly seen as a valuable commodity as a raw material for new ICT equipment, as well as being considered undesirable from a sustainability perspective.
Ev5	**Disease** — after 70 years of successful use, the effectiveness of antibiotics is lessening as more microbes are evolving to become resistant. In a more connected world and also because of climate change, the risk of pandemics and diseases arriving in Europe from other parts of the world becomes higher.
Category: POLITICAL	
Sub-category: Political Agenda	
P1.1	**The European digital single market** — is one of the European Commission's ten priorities. A digital single market in Europe could create hundreds of thousands of jobs and bring EUR 415 billion to the EU economy each year.
P1.2	**e-government** — the prevalence of e-government across the EU varies substantially but is increasing everywhere.
P1.3	**Security and privacy** — these are two sides of the same coin; as governments believe they need to monitor internet communications more thoroughly to prevent terrorism, the public may begin to become more concerned about its privacy.

P1.4	**Investment in education and employment initiatives** — it will be increasingly difficult for governments to find funds for education and employment initiatives owing to competing demands for expenditure.
P1.5	**Control of migration** — the recent surge in migration from the Middle East and Africa has led to major re-thinking of immigration policies across Europe.
P1.6	**Regulation of new working patterns** — many new working patterns are not well served by existing regulations.
P1.7	**Governance of ICT-ETs** — as use of ICT-ETs has increased, there has been a corresponding increase in demand for the regulation of their use, as well as concern about inappropriate regulation or over-regulation.
Sub-category: Instability	
P2.1	**Terrorism and war** — terrorist attacks in European capitals cause a reduction in travel and concerns about living/working in large cities. Generally these effects wear off after a while, but if attacks were to increase in frequency and severity then there could be a noticeable effect on patterns of behaviour.
P2.2	**Increasing geopolitical volatility** — the geopolitical landscape is currently constantly and rapidly changing.
P2.3	**Blurring of borders** — increased globalisation, the rise of digital work platforms and an increasingly networked world mean that borders may become blurred or even cease to exist.

4 Identification of key trends and drivers of change (Task 3)

4.1 Purpose

The scenarios to be developed in Work Package 2 will be based on the consolidated trends and drivers of change listed in section 3.5 (see Appendix J for full descriptions) and their associated uncertainties and interactions. To determine the most appropriate framework (axes) for the scenarios, the trends and drivers that generate the 'critical uncertainties' need to be identified. These are the ones that have a major impact on the future nature and location of work and for which the outcomes are uncertain, thereby creating the key differences between the scenarios. The trends and drivers that have a major impact but have more predictable outcomes are also important for scenario development; these, therefore, also need to be identified, so that they can be taken into account across all the scenarios.

4.2 Prioritisation methodology

4.2.1 Overview

The methodology used to identify the key trends and drivers of change was a two-step process. First of all, the results from the interviews and the Delphi-like web surveys were reviewed to prioritise and group together trends and drivers that were related in terms of their potential impact (see section 4.2.2.). The complete set of 91 consolidated trends and drivers as prioritised and arranged into 25 groups were then considered in order to select the key trends and drivers during a mini-workshop, on 17 October 2016, attended by the full project team (i.e. staff from HSL, SAMI and EU-OSHA) and a few experts who had not,

until then, been involved with the project (to reduce the likelihood of 'group-think'[4]). For a complete list of all those who participated in this mini-workshop, see Appendix K.

The key trends and drivers identified during the mini-workshop will be those used to determine the most appropriate framework for the scenarios in Work Package 2. While the key trends and drivers determine the framework, none of the consolidated trends and drivers listed in section 3.5 will be excluded from consideration during the scenario generation.

4.2.2 Initial prioritisation

To prioritise the trends and drivers to be considered at the mini-workshop, all the data from the Delphi-like web surveys and the interviews were reviewed and, where necessary, reference was made back to the information recorded during horizon scanning.

The first web survey results for each STEEP category, shown in Figures E1 to E5 in Appendix E, provided quantifiable data on the priority of the drivers and were an important part of the selection process. The comments made in response to the open questions in this first web survey provided useful additional information. The number of times something related to each trend or driver was referred to in the interviews was also used for the prioritisation. Interviewees were asked which trends or drivers they thought would have the greatest impact on ICT and work location, so the number of references was an indicator of the relative priorities. The comments made by participants in the second (follow-up) web survey (see section 3.4.2) about the prioritisation of drivers resulting from the first web survey for each STEEP category (see Tables E1 to E5) were also taken into account, in particular where other factors were raised. These were, in particular, useful for understanding any differences between the number of references by interviewees that related to the drivers and the rankings resulting from the first web survey.

Consideration was also made of the possibility that the web surveys' results could be biased towards 'current drivers' or issues that featured heavily in the media while the surveys were open. It was important that any possible bias did not result in the 'weak signals of emerging trends or drivers of change' being filtered out, as these might be important for the ends of the scenario timelines. In assessing weaker signals account was taken, in particular, of comments made during the interviews and in the follow-up web survey. Reference was also made to the raw horizon-scanning data collected in Task 1 to help identify weaker signals, as these recorded both the impact and the timescale of drivers against the three-horizons model, as shown in Figure 1.

The final stage of the prioritisation was to look at the overall spread of the drivers to ensure that they covered the key issues for the project, including those highlighted in the interviews. Account was taken of the context of the project. For example, the European digital single market was not highly scored in the web survey, but it was felt important that it should form part of the discussion at the workshop.

Some of the drivers have been modified based on comments made during the consultation. However, it was not considered that any of these changes invalidated their relative scores. A few drivers were combined and in these cases their scores were also combined. Two new drivers were identified from the interviews. As these had not been part of the Delphi-like web surveys, it was decided that they should also be considered at the mini-workshop.

4.2.3 Mini-workshop

The outcome of the initial prioritisation was sent in advance of the mini-workshop, on 17 October 2016, to all invited participants. During the mini-workshop, participants first considered whether they were happy with the prioritised groups and made any changes that they agreed were necessary. This involved:

- discussing whether any other trends and drivers from the consolidated list in Table 1 (i.e. those not included in the prioritised list) were as important and adding them to the groups that they agreed, by consensus, were the most appropriate;

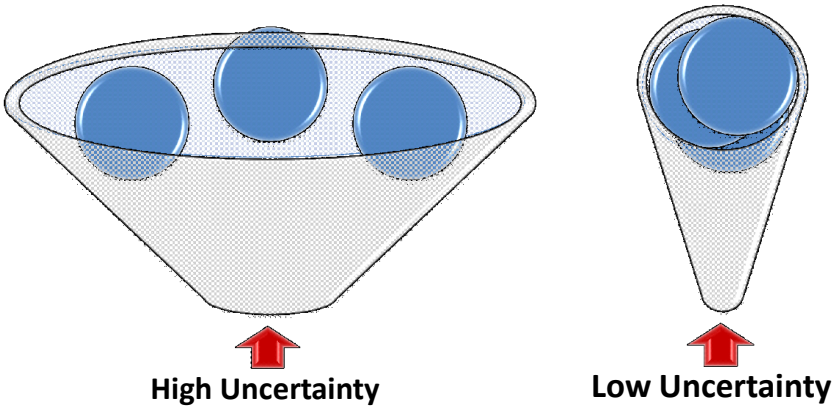
[4] A psychological phenomenon that occurs within a group of people, who have been working together, in which the desire for harmony prevents individuals in the group from properly considering alternative viewpoints of their own or others.

- moving individual trends and drivers from one group to another (including from one STEEP category to another);
- merging similar groups from different STEEP categories;
- adding any new trends and drivers of change that they considered were missing.

Participants first ranked the groups in terms of whether they were high impact by comparing each group with all the others. They then selected those trends and drivers that they thought not only had a high impact but also had high levels of uncertainty associated with them and identified the associated critical uncertainties. During this process, it was important not to confuse uncertainty with probability. High uncertainty is where a trend or driver of change can result in diverse outcomes, as illustrated in Figure 6. For example, if economic growth could be accurately forecast to 2025, this would be low uncertainty; but if there could be a significantly wide range of potential rates of growth, it would be high uncertainty even if each had a similar probability of happening. In addition, several groups of technology trends and drivers were identified that were high impact but for which the only uncertainty was how quickly the technology would become available and be adopted.

Figure 6: Unc

Figure 17: Uncertainty of key driver of change



The high impact, low uncertainty trends and drivers, which are likely to be predictable, are likely to have a similar impact across all the selected scenarios. Those trends and drivers that are both high impact and high uncertainty are known as critical uncertainties. The resulting list of key trends and drivers, which can be found in section 4.4.2, is made up of groups of trends and drivers that fell into the top right quadrant of the matrix shown in Figure 7 and also a group that fell into the bottom right quadrant.

Figure 7: Matrix for identifying key trends and drivers

Low Impact High Uncertainty	**High Impact** **High Uncertainty** **Critical Uncertainties**
Low Impact Low Uncertainty	High Impact Low Uncertainty (Predictable)

4.3 Results of initial prioritisation

Of the 91 consolidated trends and drivers, 50 were prioritised as a result of the consultations; these were 12 societal, 15 technological, 12 economic, 4 environmental and 7 political trends and drivers. Individual trends and drivers that were similar or related to one another were then grouped together. The result was 25 individual or small groups of (between 2 and 4) trends and drivers of change, each of which was given a representative name, as shown below.

Societal:

1. Inequality and polarisation
2. Workforce demographics
3. ICT knowledge and skills
4. Virtual and flexible working
5. Online environment and attitudes
6. Changes to human resources management

Technological:

7. Cybersecurity
8. Artificial intelligence
9. Internet of things
10. Big Data
11. Robotic technologies
12. Advanced networking and mobility
13. New standards
14. Human interfaces
15. User-centred design

Economic:

16. Economic environment
17. Industry structures
18. Data-enabled economy
19. Micro and small enterprises
20. Availability of investment funding

Environmental:

21. Resources and the environment

Political:

22. Security
23. Regulation of new work patterns
24. Education and employment initiatives
25. European digital single market

4.4 Results of mini-workshop

4.4.1 Overview

During the mini-workshop on 17 October 2016, the following trends and drivers were agreed to be key ones owing to their impact and/or uncertainty when considered together in the 17 groups shown. Some groups contain trends and drivers from the technological STEEP category only; other groups contain trends and drivers from two or more of the STEEP categories. Each group has been given a name or label for ease of reference during the scenario development in Work Package 2.

The first column either indicates that the trend/driver was new (i.e. generated during the mini-workshop) or shows the reference given to each trend or driver in the consolidated list (see section 3.5) The second column gives the short descriptions as found in the consolidated list or as written down during the mini-workshop.

4.4.2 List of key trends and drivers

High impact, high uncertainty trends and drivers

1. Virtual and flexible working

S2.1	**Flexible working patterns** — includes growth in demand (from organisations and/or individuals) for flexible working hours; part-time (voluntary and involuntary); zero-hours contracts (or on-demand workers); shorter-term temporary contracts; self-employment; home working; mobile and shift working.
S2.2	**Virtual workplaces** — working online anywhere and any time, such that location is irrelevant.
S2.3	**Crowd-working** — whereby an online platform is used to enable organisations or individuals to access an indefinite and unknown group of other organisations or individuals to provide specific services or products in exchange for payment.
New	**Tax planning and avoidance** — one outcome of virtual and flexible working would be significant changes to tax collection for both individuals and companies.

2. Supply chains and distribution

Ec3.3	**Alternative distribution chains and manufacturing** — increasing sales direct to consumers, between peers and consumer to consumer.
Ec3.5	**Increase in e-commerce** — driven by the increasing pervasiveness of mobile internet devices; has resulted in an ongoing decline in retail jobs but more logistics jobs.
Ec3.8	**Sub-contracting** — the growth of the self-employed and increased globalisation tends to drive a growth in sub-contracting.

3. Micro- and small enterprises

Ec3.1	**Micro-enterprises and small and medium-sized enterprises** — globally, there is an ongoing rise in the number of micro-enterprises and small and medium-sized enterprises (SMEs).
Ec3.4	**Rise of the entrepreneur** — digital technologies help the entrepreneur of the future, as they allow low start-up costs and fast scale-up.
Ec4.1	**Sharing economy** — the sharing rather than owning of assets such as cars appears to appeal to the 'millennial' generation, so can be expected to grow further and may extend more into sharing of work equipment, along the lines of a modern equivalent of agricultural cooperatives.
New	**Pseudo self-employment** — the 'gig economy', in which temporary jobs are common and organisations contract with independent workers for short-term engagements, and zero-hours contracts.

4. European digital single market

P1.1	**The European digital single market** — is one of the European Commission's ten priorities. A digital single market in Europe could create hundreds of thousands of jobs and bring EUR 415 billion to the EU economy each year.
P1.6	**Regulation of new working patterns** — many new working patterns are not well served by existing regulations.
P1.7	**Governance of ICT-ETs** — as use of ICT-ETs has increased, there has been a corresponding increase in demand for the regulation of their use, as well as concern about inappropriate regulation or over-regulation.

5. Economic environment

Ec1.1	**Changes in levels of globalisation** — have shown fairly steady growth from 1980 and expectations are that they will continue apace; however, there are also some indications that the trend may slow down or even reverse.
Ec1.2	**Offshoring** — is currently used by the majority of large companies for manufacturing. While there is uncertainty about whether this will continue to rise, there is expected to be a rise in the offshoring of knowledge-based work facilitated by the digital economy and crowd-working.
Ec1.3	**Reshoring** — there is some evidence that ICT advances such as 3D printing and automation, along with concerns about quality and rising costs, are beginning to create a trend towards companies moving their manufacturing closer to home.
Ec2.1	**EU growth since the financial crash of 2008** — assumptions of steady growth across Europe have been challenged and public debt limits are putting constraints on investment.
Ec2.4	**Availability of investment funding** — innovation and developments in and the diffusion and use of ICT are reliant on the availability of investment funds, either from private companies or governments.

6. ICT knowledge and skills

S3.2	**Gaps in ICT skills** — owing to growth in demand, the pace of change leading to skills becoming quickly outdated, and declining numbers of people studying science, technology, engineering and/or mathematics.
S3.6	**Quickening pace of knowledge transfer** — driven by instantaneous global communication and increasing networking.
P1.4	**Investment in education and employment initiatives** — it will be increasingly difficult for governments to find funds for education and employment initiatives owing to competing demands for expenditure.
New	**More frequent and significant shifts in the skills required for work**

7. Online environment and attitudes

S4.2	**Attitudes to online privacy** — people may be concerned about privacy and security of data, but they may still be willing to share data online because of the convenience this brings with it.
S4.3	**Public attitude to (acceptance of and demand for) ICT developments and ethics** — major new developments will be dependent on the acceptability of and demand for the technology,

	which is dependent on whether it is seen as a threat to people's preferred way of life/social model or ethics.
New	**Technology adoption rates** — time taken for technology to be fully adopted.
S4.5	**Discrimination, violence and bullying** — facilitated by the rise in the use of ICT-ETs and social networking at work.

8. Collective action

P1.3	**Security and privacy** — these are two sides of the same coin; as governments believe they need to monitor internet communications more thoroughly to prevent terrorism, the public may begin to become more concerned about its privacy.
S4.4	**The future of collective action** — there is diversity in union density across the EU; however, the general trend is a fall in trade union membership. New online platforms for collective action may spring up to replace trade unions.
T5.1	**Social media** — is increasingly popular as a tool to enable individuals and businesses to communicate, network and collaborate across the world.
T5.3	**Open intellectual property movement**[5] — concern has been expressed that unless Europe moves to an open data model, the digital economy is unlikely to progress.

High impact, lower uncertainty trends and drivers

9. Data and the knowledge economy

Ec2.2	**The economic value of data** — in order to create a data-enabled economy, there is a need for data to be valued economically and included on balance sheets. Data sets could be traded through a regulated framework.
Ec3.6	**Increasing knowledge economy** — is an ongoing trend towards trading in knowledge and information rather than physical artefacts.
T5.2	**Cloud computing** — allows workers across the world to work together by sharing data and information. By 2020, the amount of data going through the cloud globally is projected to be over double the amount in 2013.

10. Workforce demographics

S1.1	**Population changes** — while the global population is rising, the EU population is slightly falling where there is also a shortage of an active workforce.
S1.2	**Ageing workforce** — while the average age in the EU is increasing, there are variations across the EU and, in general, lower average ages in candidate countries.
S1.3	**Increasing migration into the EU** — caused by large differences in standard of living between countries and refugees from conflict, facilitated by mobile devices providing ease of access to information about different countries and travel options.

[5] This trend/driver is also relevant to data and the knowledge economy group but was put here owing to its being a form of collective action and the relatively high uncertainty associated with the extent to which it will be adopted.

P1.5	**Control of migration** — the recent surge in migration from the Middle East and Africa has led to major re-thinking of immigration policies across Europe.
S1.4	**Generational differences** — the increasing length of working life means more generations in the workplace, from the 'digital natives' to those who have been working for some time, who are coming close to retirement age or who have already retired, with very differing attitudes to hierarchical organisational structures, sharing information online and ease of using ICT at work.
S1.5	**More women in the workforce** — who tend to prefer and/or be more willing to have flexible working patterns.
S1.6	**Increasing number of workers with chronic and complex health problems** — (including MSDs, cancers, mental health disorders, etc.) and the need for more inclusive and adapted workplaces, increased incentives at policy level and awareness-raising initiatives.

11. Built-in OSH

T1.7	**User-centred design** — if technology is designed with the end-user's needs and OSH in mind, then it is more likely to be widely and successfully adopted.
New	**Safety cases** — how to handle patching in safety-of-life systems.

Key technologies

12. Robotics, autonomy and artificial intelligence

T2.2	**Robotics and collaborative robots** — robots are becoming capable of carrying out ever more intricate tasks and of operating alongside people. They are also increasingly autonomous and self-learning.
T2.4	**Artificial intelligence (AI)** — is typified by machines making rules-based decisions autonomously from an operator; increasingly, machines are able to learn from experience.
T2.6	**Additive manufacturing** — also called rapid manufacturing or 3D printing, is an automated process that produces three-dimensional objects directly from digital models by the successive addition of materials.
T2.7	**Autonomous vehicles (AVs)** — are increasingly being used on private land and being tested on public highways worldwide. Interim features, such as self-parking and collision avoidance assistance, are already being deployed.
T2.8	**Drones** — their use for work purposes is expanding rapidly and this is expected to continue in the future.

13. Internet and Big Data

T1.5	**Internet of things** — potential for vast numbers of cheap sensors taking measurements opens up a wealth of possibilities for machine to machine (M2M) communication and pervasive sensors, especially when combined with Big Data analytics and machine learning.
T1.6	**Big Data - i**s a combination of three trends: increasing rate of data generation; improving data storage; and advancing data analysis.

T2.5	**Industry 4.0** - The 'Internet of Things' and machine to machine (M2M) communication is enabling an emerging trend of 'lights out' manufacturing (manufacturing without human involvement).
New	**Transparency of algorithms** — making the algorithmic structures of autonomous systems or artificial intelligence clear and accessible.

14. Cybersecurity

T5.7	**Cybersecurity** — attacks on companies' assets and services through their IT are becoming increasingly sophisticated and difficult to detect.
New	**Formal methods** — ability to demonstrate that software correctly implements the appropriate mathematical models.

15. Virtual and augmented reality

T4.1	**Augmented reality (AR)** — provides contextual visual information alongside real-world views.
T4.2	**Virtual reality (VR)** — the use of computer technology to create a simulated, immersive 3D environment that can be interacted with. VR systems primarily use head-mounted displays (HMDs) but can also use a display screen.

16. Communications networks

T1.4	**Need for new standards** — to enable more and more different technological devices to 'talk' to each other. A lack of common standards may limit ICT advances.
T3.1	**Growth in mobile ICT devices** — as a result of increasing computing and battery performance, coinciding with miniaturisation, faster and more widespread access to WiFi, 5G and beyond.
T5.4	**Advanced networking, internet and WiFi protocols** — advances in networking that will enable a far more secure, transparent, flexible, verifiable, instantaneous and functional network.

17. Human interfaces

T2.3	**Bionics** — robotic-based technologies can be used to augment human activities and strength or to overcome disabilities, for example through exoskeletons. Such devices are becoming increasingly available, affordable and capable.
T4.4	**Interfacing via other human senses** — such as via gesture control, eye tracking technology, speech recognition and instantaneous translation; these technologies are becoming increasingly capable and ubiquitous.
T4.5	**Direct –computer-to-brain interfaces (invasive and non-invasive)** — computer-to-brain interfaces including those aiming to produce perceptions by stimulating the brain are being researched and developed.

Trends considered to be outcomes rather than key drivers

The following two were considered to be important outcomes of various trends and drivers rather than trends and drivers in themselves.

S2.5	**Changes to HR management** — these range from surveillance and monitoring of workers' location, activity and productivity by data profiling to flatter organisational structures where workers are supervised less, have more autonomy and are judged by innovation as well as output, rather than just time spent at work.
S1.7	**Inequality and polarisation** — owing to the benefits from technological innovation not being spread evenly across socio-economic groups, with low-paid unskilled workers at one end of the spectrum and a 'digital elite' at the other. This could be to such an extent that it causes social unrest and increased migration.

Wildcards

The following two drivers were considered to be 'wild cards' that could apply to any or all of the scenarios.

P2.1	**Terrorism and war** — terrorist attacks in European capitals cause a reduction in travel and concerns about living/working in large cities. Generally these effects wear off after a while, but if attacks were to increase in frequency and severity then there could be a noticeable effect on patterns of behaviour.
P2.2	**Increasing geopolitical volatility** — the geopolitical landscape is currently constantly and rapidly changing.

4.4.3 Useful observations made by participants during the mini-workshop

A number of interesting observations were made by participants during the mini-workshop. These have been recorded below, as they may be useful in building a narrative for the scenarios developed during Work Package 2.

- Some aspects of ICT can be discriminatory in the context of an increasingly diverse workforce.
- There is a drive towards digital by default, so it is important that the social and OSH implications of this are properly considered.
- The Internet of Things could lead to a large number of gadgets that are inadequately protected against cybercrime.
- The advent of quantum computing may happen more quickly than expected and would undermine current encryption technology, making cybercrime much more likely.
- Current demographics could lead to problems due to different generations having fixed attitudes towards other generations that could be discriminatory. More older people in work could lead to a lack of opportunities for entrants into the job market (younger people, mothers). One solution could be more job-sharing. The increased use of robots and AI should also be considered as an element of demographics.
- The upskilling required by AI could lead to a hollowing out of the workforce, that is, quite a few high-quality/skilled jobs and a lot of low-quality/unskilled jobs but very few in between. There is also the risk that a powerful digital elite could have too much influence on policy making. However, AI, when used as a support tool, could open up some jobs that previously required specialist skills to a broader range of people.
- There could be a rapid turnover in terms of jobs and skills. Up to 47 % of jobs could be affected. New jobs will be created but possibly not as many or as fast as old jobs disappear. It may also be

difficult for people to move from disappearing jobs to new jobs owing to lack of the necessary skills; lost jobs in one industrial sector and new jobs in a different, unfamiliar, sector; or geographical location (although this may be less of an issue as new jobs are more likely not to require working in a fixed location). If people are, as a result, excluded from work or suffer job insecurity, there could be direct mental and physical health consequences.

- As the use of AI spreads, although younger workers are likely to be better equipped in terms of the necessary ICT skills, social skills and experience are also likely to become increasingly important. This could result in rising job opportunities for older workers, while young workers' skills might be more easily replaceable by AI.
- As AI makes the way we interact with ICT easier and more like normal human interactions, the ICT skills required to benefit from new technology will be reduced. However, AI can make unforeseeable and possibly unrecognisable decision errors.
- The Internet of Things could create very complex systems that are difficult to properly understand and manage.
- There could be a rise in home-based craft industries.
- Social and religious norms may be unable to keep up with the pace of change in technology, particularly AI. This is because social science tends to develop in a linear way while technological innovations are developing exponentially. If they do not converge at some point, there will be a crisis and OSH might be negatively affected.
- There could be a severe backlash (e.g. riots or revolution) against technology, increased surveillance, or current business or political models as a result of perceived unreasonable treatment of particular groups of workers, such as young people or those losing their jobs in large numbers due to automation or AI. Interracial behaviour and the tribal nature of humans, with the potential for this to be exacerbated by social media, could also play a part.
- There seems to be a new type of machismo — instead of people taking physical risks so as not to look weak, they are now saying, 'I can cope with 24/7 working and will answer all emails immediately.' However, younger workers (or 'whizz-kids') who think they can cope are just as likely, if not more likely, to experience burnout earlier than those who are not digital natives.
- Disease is considered by many scientists to be one of the biggest existential threats to mankind this century because it spreads so easily in modern cities and owing to the increased ease and speed of travel, particularly by aeroplane. As antibiotics struggle, the potential for bioterrorism is increasing rapidly.

5 Discussion

This is the final report on Work Package 1 of the foresight project on new and emerging risks associated with ICT and associated changes in the nature of work, including work location. The purpose of Work Package 1 was to produce a set of key trends and drivers of change to inform the development of scenarios for the future during Work Package 2. Producing the set of key trends and drivers was done through three distinct tasks.

- Task 1 produced an initial set of trends and drivers of change through the process of horizon scanning.
- Task 2 consolidated these by consultation with experts via telephone interviews and two Delphi-like web surveys.
- Task 3 involved reaching consensus on what were the key trends and drivers of change during a mini-workshop attended by the project team, EU-OSHA project managers and several invited experts.

The primary objective of the telephone interviews in Task 2 was to provide qualitative information to supplement the findings from the horizon scanning in Task 1. However, the size of the data set also allowed the number of references made by interviewees to something that related to different trends and drivers, which was not intended as a quantifiable ranking, to be usefully used as an input into prioritising them.

The first round of the Delphi-like web surveys in Task 2 was aimed at providing quantifiable data for the prioritisation of the trends and drivers of change. Obtaining 114 usable responses from 22 different countries was particularly good for such a survey. This was most likely due to the use of a range of different channels to raise awareness of the survey, including newsletters with a large circulation and social media posts by members of the project team and their colleagues who have a large number of followers. The numbers of respondents who chose which trends and drivers they considered most important were more than sufficient to inform the prioritisation of the trends and drivers. However, there was some evidence that 29 trends and drivers to choose from per category is an upper limit for surveys of this nature. There were not sufficient numbers disagreeing with any one specific trend or driver to justify deleting it from the consolidated list.

The range, depth and quality of the responses made to the open questions in the first round of the Delphi-like web survey provided useful additional information to supplement that from the horizon scanning. The responses also demonstrated a high level of understanding of and interest in the topic. Interest and understanding were also reflected in the self-declared levels of expertise and the 160 downloads of the consultee briefing document while the surveys were open. The final 'Oracle' question provided a useful insight into the issues of particular concern to respondents.

The response rate for the second round of the Delphi-like web survey was much lower, just 11 responses, which were all from respondents to the first web survey. The most likely reasons for the low response rate were the timing of the survey, during the long summer vacation, and the fact that it was not promoted via OSHmail. Another reason may have been that people did not feel qualified to comment, which is supported by the fact that not all respondents commented on all the categories, and by one respondent's comment to the effect that they thought people might not have understood the concepts in the survey. While the sample was small, the responses proved very valuable in interpreting and testing the results of the first web survey. The areas where participants in the second web survey disagreed with the results of the first web survey tended to be those where there was variation between the rankings of the trends and drivers of change in the first web survey and the number of references made to them in the interviews.

Experts engaged well with the various different means by which they were consulted. This was reflected by the considerable amount of valuable relevant information generated, the duration of the interviews, and the quantity and quality of responses in the Delphi-like web surveys to the open questions.

There was some indication that the voting for trends and drivers in the first web survey and some of the comments made during some of the interviews were influenced by current thinking and media reporting on recent events. It was, therefore, important to ensure that weak signals of longer term trends and drivers were also taken into account in the analysis. The second web survey, despite a low response rate, was particularly useful in providing data that helped identify these weaker signals.

There was also good engagement of participants at the mini-workshop during which the key trends and drivers of change were agreed. This allowed differences to be raised and then resolved through discussion and debate. In some cases, the potential outcome and consequent impact were very uncertain and in others while the impact was high it was also more certain.

The 92 trends and drivers identified through the horizon scanning were condensed to 17 groups of key trends and drivers as a result of the consolidation and selection exercises of this work package. It should be noted that a few trends and drivers could have been placed in more than one group. The groups these appear in are, however, those chosen by the participants during the mini-workshop. During this process, the environmental group of trends and drivers was demoted. Two trends and drivers were also demoted because they were considered to be outcomes rather than trends and drivers of change and two were considered to be wildcards. During the final selection of key drivers at the mini-workshop in Task 3, 13 trends and drivers not originally prioritised as a result of the Task 2 consultation were added back and, in addition, 7 new trends and drivers were created by participants. As these new trends and drivers were added at the workshop, they did not undergo the same rigorous evaluation as those identified during the horizon scanning, which were subjected to peer review through the telephone interviews and two web surveys. These should, therefore, be treated with some caution, as some are more akin to observations than trends and drivers as such.

6 Conclusions

The horizon scanning in Task 1 identified 92 trends and drivers of change that may impact on the development of ICT-ETs and associated changes to the nature of work and work location. These have been successfully consolidated, in Task 2, through consultation with experts who are aware of trends and drivers of change that may not yet be described in published material. This was done through telephone interviews with a purposive sample of experts and a self-selecting sample of respondents to two openly available and widely promoted Delphi-like surveys. The data sets obtained complemented one another and, on the whole, reinforced one another, such that when taken together they robustly informed an initial prioritisation of the trends and drivers. The analysis would have been much weaker without all three elements. However, it was also important for the project team to use their judgement in interpreting the results.

The detailed information for each of the consolidated trends and drivers, which can be found in Appendix J of this report, along with the raw data collected during the horizon scanning, will provide a useful research resource during the rest of this foresight project and probably also after the project has been completed.

It was found that there was considerable interaction between the trends and drivers. The following overall observations can be made:

- A major challenge for the application of employment and social security laws, as well as for education and training approaches, relates to a more diverse and less well-defined workforce and to changes introducing more flexible working patterns, which are expected to be brought about by an increase in the prevalence and spread of ICT-ETs. This is because ICT-ETs allow much work to be done virtually anywhere and at any time, and it is expected to fundamentally change traditional employer-employee relationships.
- Although the spread and prevalence of ICT-ETs are currently varied across sectors, ICT is now generally seen to be part of many sectors rather than as a sector of its own, and ICT-ETs are expected to continue to increase across them all, although not necessarily uniformly.
- The spread and prevalence of the application of ICT-ETs are also currently varied across Europe and across different socio-economic groups.
- There is also evidence that over the next decade there are likely to be significant and accelerating changes in relation to ICT-ETs, which will considerably change the nature of work across Europe and affect most people in some way. This will have the potential to create business opportunities, including stimulating increased productivity and growth in Europe, with the possibility of inequality in the benefits and disadvantages experienced by different workers. It is difficult to predict these changes, so the scenarios will be a valuable tool to help inform EU decision-makers, Member States' governments, trade unions and employers, and to enable them to take appropriate account of changes in ICT-ETs when making decisions to shape the future of OSH towards safer and healthier workplaces.

The resulting 17 groups of key trends and drivers include:

- key technologies such as robotics, automation, autonomous vehicles, drones, AI, the Internet of Things, Big Data, novel human-machine interfaces and communications networks, as well as related issues such as cybersecurity, and their impact on the nature of work;
- how ICT-ETs will affect the nature of work, that is, the type of work that will be done, how, where and when it will be done, who will do it and, with the emergence of new employment patterns, employee-employer relationships;
- business models, supply chains and the economic environment;
- various demographic changes leading to a diverse workforce, such as migration, increasing participation of women in the labour market and the ageing workforce, and related issues such as increasing chronic and complex health issues in the workforce, as well as multigenerational and cultural differences;
- attitudes towards and demand for ICT-ETs, the governance of them and the resulting new working patterns.

The key trends and drivers, when considered as a whole, seem to indicate that the pace of change of ICT-ETs and how they are adopted in the workplace are likely to be affected by how demand for and acceptance of ICT-ETs by the public and workers, governance and investment-related decisions support innovations in ICT-ETs (particularly robotics, autonomy and AI), which drive changes in the nature of work and business structures (particularly rapid job changes and turnover).

Several trends and drivers may provide OSH benefits, primarily by removing people from hazardous environments but also by providing new opportunities for communicating good OSH practice. However, many trends and drivers are associated with OSH risks, which mainly appear to be psychosocial (e.g. relating to the emotional and cognitive load associated with the 24/7 economy, permanent connectivity, loss of traditional working hierarchies and social interaction at work) and ergonomic (e.g. relating to the increase in the use of mobile devices and new human-machine interfaces). Concerns raised during the consultation with experts were primarily psychosocial. Many comments were made about work-related stress, emotional and cognitive overload in relation to automation and the 24/7 economy, for example:

- ‘if all routine work is automated, what remains is only the hard part’;
- ‘everything becomes too much’;
- ‘always on [connected], creating a blurring of work-life balance’;
- ‘the ability of workers to control their work is key to reducing stress’.

There were also comments about bullying and discrimination, and whether the new types of jobs and working patterns would provide sufficient employment to provide workers with a living wage. This forms a useful preliminary indication of the potential impact of the trends and drivers on ICT-ETs, the nature and location of work and potential OSH implications, which will be explored in greater depth when developing scenarios for the future in Work Package 2.

The overall conclusion from this work package is that there is a high degree of confidence that the identified key trends and drivers of change are a robust set suitable for generating the scenarios in Work Package 2. The final 17 groups of key trends and drivers have, therefore, fulfilled the primary objective of Work Package 1 (on which this is the final report).

7 References

Biewald, L. 2015. 'Artificial intelligence and the future of work'. Retrieved 23 June 2016 from: https://medium.com/the-wtf-economy/artificial-intelligence-and-the-future-of-work-a0eaabea7c41#.l6npsgsll

Bolognini, A. and Legovini, E., 2012. 'Roadmap to digital single market — Prioritising necessary legislative responses to opportunities and barriers to e-commerce'. Note for European Parliament's Committee on Internal Market and Consumer Protection. European Parliament, Brussels. Available at: http://www.europarl.europa.eu/document/activities/cont/201209/20120914ATT51402/20120914ATT51402EN.pdf

Cardona, M., Duch-Brown, N., Francois, J., Martens, B. and Yang, F., 2015. 'The macro-economic impact of e-commerce in the EU digital single market'. Institute for Prospective Technological Studies Digital Economy Working Paper 2015/09, JRC98272. Joint Research Centre of the European Commission. Available at: https://ec.europa.eu/jrc/sites/default/files/JRC98272.pdf

Cisco, 2016. 'Cisco Visual Networking Index (VNI): 'Global mobile data traffic forecast update, 2016-2021'. Available at: http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.pdf

Degryse, C., 2016. 'Digitalisation of the economy and its impact on labour markets'. ETUI Working Paper. ETUI aisbl, Brussels. Available at: https://www.etui.org/Publications2/Working-Papers/Digitalisation-of-the-economy-and-its-impact-on-labour-markets

Department for Occupational Safety and Health Finland, 2015. *Working life 2025 review: Effects of working life and the working environment on occupational safety and health and well-being at work*. Reports and memorandums of the Ministry of Social Affairs and Health 2015:41. Available at: https://www.julkari.fi/bitstream/handle/10024/126974/RAP2015-45.pdf?sequence=1

Dolphin, T., 2015. *Technology, globalisation and the future of work in Europe: Essays on employment in a digitised economy*. Institute for Public Policy Research (IPPR), London. Available at: http://www.ippr.org/files/publications/pdf/technology-globalisation-future-of-work_Mar2015.pdf

EU-OSHA (European Agency for Safety and Health at Work), 2009. *The human machine interface as an emerging risk*. Available at: https://osha.europa.eu/en/publications/literature_reviews/HMI_emerging_risk/view

EU-OSHA (European Agency for Safety and Health at Work), 2013a. *Green jobs and occupational safety and health: Foresight on new and emerging risks associated with new technologies by 2020*. Available at: https://osha.europa.eu/en/tools-and-publications/publications/reports/green-jobs-foresight-new-emerging-risks-technologies

EU-OSHA (European Agency for Safety and Health at Work), 2013b. *Priorities for occupational safety and health research in Europe: 2013-2020*. Available at: https://osha.europa.eu/en/tools-and-publications/publications/reports/priorities-for-occupational-safety-and-health-research-in-europe-2013-2020/view/

EU-OSHA (European Agency for Safety and Health at Work), 2014. *Scoping study for a foresight on new and emerging occupational safety and health (OSH) risks and challenges*. Available at: https://osha.europa.eu/sites/default/files/publications/documents/en/publications/reports/scoping-study-for-a-foresight-on-new-and-emerging-osh-risks-and-challenges/Dos%20613%20-%20for%20publication.pdf

EU-OSHA (European Agency for Safety and Health at Work), 2015. 'A review on the future of work: online labour exchanges, or "crowdsourcing": Implications for occupational safety and health'. Available at: https://osha.europa.eu/en/tools-and-publications/publications/future-work-crowdsourcing/view

EU-OSHA (European Agency for Safety and Health at Work), 2016. 'Review of drivers and trends of change in information and communication technologies and work location: Briefing for

consultees'. Available at: https://oshwiki.eu/images/f/ff/Summary_report_Key_trends_and_drivers_of_change.pdf

European Commission, 2010. Communication from the Commission, 'Europe 2020: A strategy for smart, sustainable and inclusive growth'. 3.3.2010 COM(2010) 2020. European Commission, Brussels. Available at: http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf

European Commission, 2014. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 'An EU strategic framework on health and safety at work 2014-2020'. 6.6.2014 COM(2014) 332 final. European Commission, Brussels. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0332

European Commission, 2015. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 'A digital single market strategy for Europe'. 6.5.2015 COM(2015) 192 final. European Commission, Brussels. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015DC0192&from=EN

European Commission, 2016a. 'Commission sets out path to digitise European industry'. Press release. European Commission, Brussels. Available at: http://europa.eu/rapid/press-release_IP-16-1407_en.htm

European Commission, 2016b. 'The Digital Economy and Society Index (DESI)'. Available at: https://ec.europa.eu/digital-single-market/en/desi

Frey, C.B., Holmes, C., Osborne, M.A., Rahbari, E., Garlick, R., Friedlander, G., McDonald, G., Curmi, E., Chua, J., Chalif, P. and Wilkie, M., 2016. *Technology at work v2.0 — The future is not what it used to be*. Citi GPS: Global Perspectives & Solutions and the Oxford Martin School. Available at: http://www.oxfordmartin.ox.ac.uk/downloads/reports/Citi_GPS_Technology_Work_2.pdf

Hartnett, M., Hodess, B., Hanson, M.S., Blanch, F., Nahal, S. and Roche, G., 2015. 'Thematic investing: Creative disruption'. Merrill Lynch, Pierce, Fenner & Smith Incorporated. Available at: https://challenges.openideo.com/attachments/b728a11b-d8c9-444f-9709-9955e7d4eb4b.pdf?id=3496

IBM, 2016. 'What is Watson?' IBM. Retrieved 11 April 2016 from: http://www.ibm.com/smarterplanet/us/en/ibmwatson/what-is-watson.html

Leopold, T.A., Ratcheva, V. and Zahidi, S., 2016. *Global Challenge insight report: The future of jobs — employment, skills and workforce strategy for the fourth industrial revolution*. World Economic Forum, Geneva. Available at: http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf

Maciejewski, M. and Dimova, M., 2016. 'Fact sheets on the European Union — The ubiquitous digital single market'. Available at: http://www.europarl.europa.eu/atyourservice/en/displayFtu.html?ftuId=FTU_5.9.4.html

Maciejewski, M., Isabel, N., Fisher, C. and Roginska, Y., 2014. 'Streaming and online access to content and services'. Study for the IMCO Committee. European Parliament, Brussels. Available at: http://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/492435/IPOL-IMCO_ET(2014)492435_EN.pdf

Mandl, I., Curtarelli, M., Riso, S., Vargas, O. and Gerogiannis, E., 2015. *New forms of employment*. Eurofound. Available at: http://www.eurofound.europa.eu/sites/default/files/ef_publication/field_ef_document/ef1461en.pdf

Massachusetts Institute of Technology Center for Digital Business, 2013. 'Digital leadership — An interview with Erik Brynjolfsson and Andrew McAfee — The second machine age: An industrial revolution powered by digital technologies'. Capgemini Consulting. Available at: https://www.uk.capgemini.com/resource-file-access/resource/pdf/second_machine_age_09_01_2013_0.pdf

Ringland, G., 2006. *Scenario planning: Managing for the future*. John Wiley and Sons, Hoboken, NJ.

Robert Half Inc., 2015. 'Get ready for generation Z'. Available at: https://www.roberthalf.com/sites/default/files/Media_Root/images/rh-pdfs/rh_0715_wp_genz_nam_eng_sec.pdf

SCENIHR (Scientific Committee on Emerging and Newly Identified Health Risks), 2015. 'Opinion on potential health effects of exposure to electromagnetic fields (EMF)'. European Commission, Brussels. Available at: http://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf

Schwab, K., 2016. *The fourth industrial revolution*. World Economic Forum, Geneva.

SUVA, 2011. 'Prospective 2029: Etude sur les futurs risques d'accidents et de maladies professionnelles et les opportunités de prévention'. Retrieved 8 August 2016 from: https://extra.suva.ch/webshop/50/5032DFB54DA837E0E10080000A630358.pdf

8 List of sources

Ajunwa, I., Crawford, K. and Schultz, J. 2017. 'Limitless worker surveillance'. *California Law Review,* 105(3)**,** forthcoming. Retrieved 11 April 2016 from: http://ssrn.com/abstract=2746211

Alkhatib, H., Faraboschi, P., Frachtenberg, E., Kasahara, H., Lange, D., Laplante, P., Merchant, A., Milojicic, D., Schwan, K., AlQuraishi, M., Burgess, A., Forsyth, D., Iwata, H., McGeer, R. and Walz, J., 2014. *IEEE Report CS 2022*. Institute of Electrical and Electronics Engineers. Available at: https://www.computer.org/cms/ComputingNow/2022Report.pdf

Allan, D., 2016. 'Here's why you will never meet Enfield Council's newest employee'. *TechRadar*. Retrieved 11 May 2016 from: http://www.techradar.com/news/software/here-s-why-you-will-never-meet-enfield-council-s-newest-employee-1323506

Altucher, J., 2016. 'The world in 2025: 8 predictions for the next 10 years'. Inc. Video. Retrieved 20 April 2016 from: http://www.inc.com/jim-koch/samuel-adams-creator-on-scaling-up-one-barrel-at-a-time.html

Amazon, 2016. 'Amazon Picking Challenge'. Retrieved 5 June 2016 from: http://amazonpickingchallenge.org/

Aon Consulting, 2010. 'Expectations vs. reality: Meeting Europe's retirement challenge'. Available at: http://www.aon.com/attachments/europes_retirement_challenge.pdf

Baraniuk, C., 2015. 'How algorithms run Amazon's warehouses'. BBC, 18 August 2015. Retrieved 6 May 2016 from: http://www.bbc.com/future/story/20150818-how-algorithms-run-amazons-warehouses

Baraniuk, C., 2016. 'Building aircraft in augmented reality is quicker and safer'. New Scientist, 2 March 2016. Available at: https://www.newscientist.com/article/2079159-building-aircraft-in-augmented-reality-is-quicker-and-safer/

BAUA (German Federal Institute for Occupational Safety and Health), 2015a. 'Individualized social-technical workplace assistance for industrial production (INDIVA) — designing individualized work assistance systems using digital human modeling'. Retrieved 5 June 2016 from: https://www.baua.de/DE/Aufgaben/Forschung/Forschungsprojekte/f2351.html

BAUA (German Federal Institute for Occupational Safety and Health), 2015b. 'Team-Mental-Models in Human-Robot-Teams: Application Scenarios and State of Technology'. Retrieved 5 June 2016 from: http://www.baua.de/en/Research/Research-Project/f2369.html

BAUA (German Federal Ministry for Labour and Social Affairs), 2015c. 'Re-imagining work green paper: Work 4.0'. Available at: http://www.bmas.de/DE/Service/Medien/Publikationen/A872-gruenbuch-arbeiten-vier-null.html

BAUA (German Federal Ministry for Labour and Social Affairs), 2015d. 'Working 4.0. Thinking about the work of the future'. Available at:

http://www.workplaceinnovation.org/nl/kennis/kennisbank/grunbuch-arbeiten-4-0--arbeit-weiter-denken--green-paper-----working-4-0--thinking-about-the-work-of-the-future----/1258?q=Green%20paper%20Working%204.0

BAUA (German Federal Institute for Occupational Safety and Health), 2016. 'Safe and healthy at work by Persuasive Technology? Experimental laboratory and field study on the effects of new forms of IT-based feedback at work'. Available at: http://www.baua.de/en/Research/Research-Project/f2327.html

BBC News, 2013. 'Amazon workers face "increased risk of mental illness"'. BBC News, 25 November 2013. Retrieved 6 June 2016 from: http://www.bbc.co.uk/news/business-25034598

BBC News, 2016. 'Cyber attacks: Two-thirds of big UK businesses targeted'. BBC News, 8 May 2016. Retrieved 9 May 2016 from: http://www.bbc.co.uk/news/uk-36239805

Beckett, S., 2015. Robo-journalism: How a computer describes a sports match. BBC News, 12 September 2015. Retrieved 13 September from: http://www.bbc.co.uk/news/technology-34204052

Beeson, H. and Harriss, L., 2015. 'Trends in ICT'. POST Note 510. Parliamentary Office of Science and Technology, London. Available at: http://researchbriefings.files.parliament.uk/documents/POST-PN-0510/POST-PN-0510.pdf

Benady, D., Charara, S., Fildes, N., Orton-Jones, C. and Shaw, S., 2015. 'Virtual Reality'. Raconteur Media. Retrieved 6 June 2016 from: https://raconteur.uberflip.com/i/616458-virtual-reality

Bernstein, A. and Raman, A., 2015. 'The great decoupling: An interview with Erik Brynjolfsson and Andrew McAfee'. Harvard Business Review. Available at: https://hbr.org/2015/06/the-great-decoupling

Bernstein, M., 2010. 'Knowledge Work 2020: The future of knowledge work and what it might mean to each of you'. Palo Alto Research Center and Xerox. Retrieved 6 June 2016 from: http://www.slideshare.net/PARCInc/knowledge-work-2020

Biewald, L., 2015. Artificial intelligence and the future of work. Retrieved 23 June 2016 from: https://medium.com/the-wtf-economy/artificial-intelligence-and-the-future-of-work-a0eaabea7c41#.l6npsgsll

Boes, A., 2015. 'Digitization: New work concepts are revolutionizing the world of work'. Social Europe, 20 November 2015. Retrieved 27 April 2016 from: https://www.socialeurope.eu/2015/11/digitization-new-work-concepts-revolutionizing-world-work/

Bolognini, A. and Legovini, E., 2012. Roadmap to digital single market — Prioritising necessary legislative responses to opportunities and barriers to e-commerce. Note for European Parliament's Committee on Internal Market and Consumer Protection. European Parliament, Brussels. Available at: http://www.europarl.europa.eu/document/activities/cont/201209/20120914ATT51402/20120914ATT51402EN.pdf

Bowles, N., 2016. 'Our tech future: the rich own the robots while the poor have "job mortgages."'. *The Guardian*, 12 March 2016. Retrieved 11 April 2016 from: http://www.theguardian.com/culture/2016/mar/12/robots-taking-jobs-future-technology-jerry-kaplan-sxsw?CMP=fb_gu

British Library, 2015. 'My digital rights: Magna Carta for the digital age'. British Library. Retrieved 18 May 2016 from: http://www.bl.uk/my-digital-rights/magna-carta-2015

British Retail Consortium, 2016. 'Retail 2020: Fewer but better jobs'. British Retail Consortium. Available at: http://www.brc.org.uk/downloads/Retail_2020_(final).pdf

Brushfield, R., 2012. 'What is portfolio working and why is it growing?' The Telegraph. Retrieved 11 April 2016 from: https://jobs.telegraph.co.uk/article/what-is-portfolio-working-and-why-is-it-growing-/

Burt, D., Kleiner, A., Nicholas, J.P. and Sullivan, K., 2014. *Cyberspace 2025: Today's decisions, tomorrow's terrain: navigating the future of cybersecurity policy*. Microsoft Corporation. Available

at: http://download.microsoft.com/download/c/7/7/c7775937-748e-4e95-85fb-24581f16b588/cyberspace%202025%20today%E2%80%99s%20decisions,%20tomorrow%E2%80%99s%20terrain.pdf

Butler, D., 2016a. 'Tomorrow's World'. *Nature,* 530(399). Available at: http://www.nature.com/polopoly_fs/1.19431!/menu/main/topColumns/topLeftColumn/pdf/530398a.pdf

Butler, D., 2016b. 'A world where everyone has a robot: Why 2040 could blow your mind'. Nature, 530(7591). Available at: http://www.nature.com/news/a-world-where-everyone-has-a-robot-why-2040-could-blow-your-mind-1.19431#onwards

Butler, D. and Fernandes, W., 2016. 'Onwards and upwards'. Available at: http://www.nature.com/polopoly_fs/7.34377!/file/Tomorrows_World_graphic_spread_POSTER.pdf

Cardona, M., Duch-Brown, N., Francois, J., Martens, B. and Yang, F., 2015. The macro-economic impact of e-commerce in the EU digital single market. Institute for Prospective Technological Studies Digital Economy Working Paper 2015/09, JRC98272. Joint Research Centre of the European Commission. Available at: https://ec.europa.eu/jrc/sites/default/files/JRC98272.pdf

Carter, J., 2016. 'Deep learning: How the mining industry got smart'. TechRadar. Retrieved 15 June 2016 from: http://www.techradar.com/news/world-of-tech/deep-learning-how-the-mining-industry-got-smart-1322890

Chase, R., 2015. Peers Inc: How people and platforms are inventing the collaborative economy and reinventing capitalism. PublicAffairs, Perseus Book Group, New York, USA.

Cisco, 2016. 'Cisco Visual Networking Index (VNI): Global mobile data traffic forecast update, 2016-2021. Available at: http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.pdf

Clegg, R., 2015. 'UK Labour Market: September 2015'. Office for National Statistics. Retrieved 25 May 2016 from: http://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/uklabourmarket/2015-09-16

Connelly, S., 2016. 'Looking further with Ford: 2016 trends — Global consumer trends and futuring'. Ford Motor Company. Retrieved 1 August 2016 from: https://social.ford.com/content/dam/campaign/media-trends/pdf/Ford-Trends-Book-2016-Interactive.pdf

Cooke, R., 2104. 'Preparing your employees for remote working'. Retrieved 11 April 2016 from: http://www.trainingzone.co.uk/develop/cpd/preparing-your-employees-for-remote-working

Coyne, I., Sprig, C., Axtell, C. and Farley, S., 2012. 'Punched from the screen — workplace cyber bullying becoming more widespread'. The University of Nottingham, Nottingham. Retrieved 11 April 2016 from: https://www.nottingham.ac.uk/news/pressreleases/2012/november/punched-from-the-screen---workplace-cyber-bullying.aspx

DataMarket, 2011. 'Classification of economic activities — NACE Rev.2: Building completion and finishing — Economical indicator for structural business statistics: Income from sub-contracting. Year: 2011'. DataMarket. Retrieved 18 May 2016 from: https://datamarket.com/data/set/1brw/multi-yearly-enterprise-statistics-subcontracting-by-size-class-for-construction-nace-rev-2-f#!ds=1brw!v7e=1:v7f=1:v7h=1:6hzl&display=choropleth&map=europe&classifier=natural&numclasses=5

Davis, N., 2016. 'Brave new world? Sci-fi fears "hold back progress of AI", warns expert'. *The Guardian*. Retrieved 14 April 2016 from: https://www.theguardian.com/technology/2016/apr/12/brave-new-world-sci-fi-fears-hold-back-progress-of-ai-warns-expert

Degryse, C., 2016. 'Digitalisation of the economy and its impact on labour markets'. ETUI Working Paper. ETUI aisbl, Brussels. Available at: https://www.etui.org/Publications2/Working-Papers/Digitalisation-of-the-economy-and-its-impact-on-labour-markets

Department for Occupational Safety and Health Finland, 2015. 'Working life 2025 review: Effects of working life and the working environment on occupational safety and health and well-being at work'. Reports and memorandums of the Ministry of Social Affairs and Health 2015:41. Available at: https://www.julkari.fi/bitstream/handle/10024/126974/RAP2015-45.pdf?sequence=1

Department of Health, 1997. 'Communicating about risks to public health: pointers to good practice'. Available at: http://www.bvsde.paho.org/tutorial6/fulltext/pointers.pdf

Dolphin, T., 2015. *Technology, globalisation and the future of work in Europe: Essays on employment in a digitised economy*. Institute for Public Policy Research (IPPR), London. Available at: http://www.ippr.org/files/publications/pdf/technology-globalisation-future-of-work_Mar2015.pdf

dorsaVi, 2016. 'Redefining workplace safety with wearable sensor technology'. Available at: http://get.dorsavi.com/ergonomics-human-factors-2016/

Duckworth, M., Williams, H. and Dunn, C., 2014/2015. 'Department for Transport horizon scanning monthly bulletins', SAMI Consulting Ltd, UK. Available on request from: reports@samiconsulting.co.uk

Duwicquet, V., Mouhoud, E.M. and Oudinet, J., 2016. 'International migration by 2030: impact of immigration policies scenarios on growth and employment'. *Foresight*, 16(2). Available at: https://www.researchgate.net/publication/262574686_International_migration_by_2030_Impact_of_immigration_policies_scenarios_on_growth_and_employment

Elborgh-Woytek, K., Newiak, M., Kochhar, K., Fabrizio, S., Kpodar, K., Wingender, P., Clements, B. and Schwartz, G., 2013. 'Women, work, and the economy: Macroeconomic gains from gender equity'. International Monetary Fund, Strategy, Policy, and Review Department and Fiscal Affairs Department. Available at: https://www.imf.org/external/pubs/ft/sdn/2013/sdn1310.pdf

Elliott, L., 2016. 'Fourth Industrial Revolution brings promise and peril for humanity'. *The Guardian*, 24 January 2016. Retrieved 29 July 2016 from: https://www.theguardian.com/business/economics-blog/2016/jan/24/4th-industrial-revolution-brings-promise-and-peril-for-humanity-technology-davos

Ericsson, 2013. 'Next generation working life — From workplace to exchange space'. Ericsson. Available at: http://www.ericsson.com/res/docs/2013/next-generation-working-life.pdf

EU-OSHA (European Agency for Safety and Health at Work), 2005. Expert forecast on emerging physical risks related to occupational safety and health. Available at: https://osha.europa.eu/en/tools-and-publications/publications/reports/6805478

EU-OSHA (European Agency for Safety and Health at Work), 2013. *Green Jobs and occupational safety and health: Foresight on new and emerging risks associated with new technologies by 2020*. Available at: https://osha.europa.eu/en/tools-and-publications/publications/reports/green-jobs-foresight-new-emerging-risks-technologies

EU-OSHA (European Agency for Safety and Health at Work), 2014. *Scoping study for a foresight on new and emerging occupational safety and health (OSH) risks and challenges*. Available at: https://osha.europa.eu/sites/default/files/publications/documents/en/publications/reports/scoping-study-for-a-foresight-on-new-and-emerging-osh-risks-and-challenges/Dos%20613%20-%20for%20publication.pdf

EU-OSHA (European Agency for Safety and Health at Work), 2015a. 'A review on the future of work: online labour exchanges, or "crowdsourcing": Implications for occupational safety and health'. Available at: https://osha.europa.eu/en/tools-and-publications/publications/future-work-crowdsourcing/view

EU-OSHA (European Agency for Safety and Health at Work), 2015b. 'A review on the future of work: Robotics'. Available at: https://osha.europa.eu/en/tools-and-publications/publications/future-work-robotics

EU-OSHA (European Agency for Safety and Health at Work), 2016. 'Safety and health in micro and small enterprises'. Available at: https://osha.europa.eu/en/themes/safety-and-health-micro-and-small-enterprises

European Commission, 2010. Communication from the Commission 'Europe 2020: A strategy for smart, sustainable and inclusive growth'. 3.3.2010 COM(2010) 2020. European Commission, Brussels. Available at: http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf

European Commission, 2014. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions 'an EU strategic framework on health and safety at work 2014-2020'. 6.6.201 COM(2014) 332 final. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0332

European Commission, 2015a. 'Connectivity — Broadband market developments in the EU'. Available at: https://ec.europa.eu/digital-single-market/en/connectivity

European Commission, 2015b. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 'a digital single market strategy for Europe'. 6.5.2015 COM(2015) 192 final. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015DC0192&from=EN

European Commission, 2015c. 'Europe 2020 indicators — employment'. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Europe_2020_indicators_-_employment

European Commission, 2015d. 'European Commission: State of the union 2015 — Progress on the European Commission's 10 priorities'. Available at: https://ec.europa.eu/commission/publications/progress-10-priorities_en European Commission, 2015e. 'Juncker Commission adopts second annual work programme: Maintaining focus and delivering on 10 priorities'. Press release, 27 October 2015. Available at: http://europa.eu/rapid/press-release_IP-15-5923_en.htm

European Commission, 2015f. *The knowledge future: Intelligent policy choices for Europe 2050*. Available at: https://ec.europa.eu/research/foresight/pdf/knowledge_future_2050.pdf

European Commission, 2015g. *Potential health effects of exposure to electromagnetic fields*. Available at: http://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf

European Commission, 2016a. Commission Staff Working Document 'Advancing the internet of things in Europe' accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 'digitising European industry reaping the full benefits of a single digital market'. 19.4.2016 SWD(2016) 0110 final. Available at: https://ec.europa.eu/digital-single-market/en/news/staff-working-document-advancing-internet-things-europe

European Commission, 2016b. 'Commission sets out path to digitise European industry'. Press release. European Commission, Brussels. Available at: http://europa.eu/rapid/press-release_IP-16-1407_en.htm

European Commission, 2016c. 'The Digital Economy and Society Index (DESI)'. 2016. Available at: https://ec.europa.eu/digital-single-market/en/desi

European Commission, 2016d. 'Europe 2020'. Retrieved 6 June 2016 from: http://ec.europa.eu/europe2020/index_en.htm

European Commission, 2016e. 'The future of work: Skills and resilience for a world of change'. Available at: http://ec.europa.eu/epsc/pdf/publications/strategic_note_issue_13.pdf

European Union, 2015. 'Eurostat statistics explained: Glossary — population pyramid'. Retrieved 18 May 2016 from: http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Population_pyramid

Ford, M., 2015. *The rise of the robots: Technology and the threat of mass unemployment*. One World Publications, London.

Foulkes, I., 2016. 'Switzerland basic income: Landmark vote looms' BBC News, 4 June 2016. Retrieved 6 June 2016 from: http://www.bbc.co.uk/news/world-europe-36443512

Frey, C. B., Holmes, C., Osborne, M. A., Rahbari, E., Garlick, R., Friedlander, G., McDonald, G., Curmi, E., Chua, J., Chalif, P. and Wilkie, M., 2016. *Technology at work v2.0 — The future is not what it used to be*. Citi GPS: Global Perspectives & Solutions and the Oxford Martin School. Available at: http://www.oxfordmartin.ox.ac.uk/downloads/reports/Citi_GPS_Technology_Work_2.pdf

Frey, C.B. and Osborne, M.A., 2013. *The future of employment: How susceptible are jobs to computerisation?* Oxford Martin School. Available at: http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

Frey, T., 2013. 'The great freelancer movement: 8 reasons why your next job will be a project'. The Futurist Speaker, 10 August 2013. Available at: http://www.futuristspeaker.com/2013/08/the-great-freelancer-movement-8-reasons-why-your-next-job-will-be-a-project/.

Fulton, L., 2013. 'National industrial relations/across Europe/trade unions'. Available at: http://www.worker-participation.eu/National-Industrial-Relations/Across-Europe/Trade-Unions2

Gallie, D., Felstead, A., Green, F. and Inanc, H., 2016. 'The hidden face of job insecurity'. *Work, employment and society*, 31(1): 1-18. Available at: http://orca.cf.ac.uk/82553/17/Gallie%20et%20al%202015.pdf

Giang, V., 2015. '5 major ways freelancers will change the economy by 2040'. Retrieved 11 April 2016, from: http://www.fastcompany.com/3049857/the-future-of-work/5-major-ways-freelancers-will-change-the-economy-by-2040

Gibbs, S., 2016. 'Huge profits in store for firm that can make a great leap in battery technology'. *The Guardian*, 21 May 2016. Retrieved 11 April 2016, from: https://www.theguardian.com/technology/2016/may/21/battery-energy-storage-technology-breakthrough

Goldberg, E., 2015. 'Facebook, Google Maps are saving refugees and migrants from traffickers'. Huffington Post, 10 September 2015. Retrieved 11 April 2016 from: http://www.huffingtonpost.com/entry/facebook-google-maps-refugees-migrants_us_55f1aca8e4b03784e2783ea4

Goodhew, P.J., 2010. *Teaching Engineering: All you need to know about engineering education but were afraid to ask*. The Higher Education Academy UK Centre for Materials Education, Liverpool.

Google, 2016. 'Google DeepMind'. Retrieved 18 May 2016 from: https://deepmind.com/

Gratton, L., Bradlow, H., Tee, B., Xu, J., Durrant-Whyte, H., McCalman, L., O'Callaghan, S., Reid, A., Steinberg, D., Gollschewsk, M., Girn, S., McKenzie, F., Bradley, T., Lewis, P., Borland, J., Coelli, M., Beitz, S., Apps, P., Phillips, K., Ruthven, P., Callander, S., Green, R., Marsh, I., Pitelis, C., Hollander, J.D., Durrant-Whyte, H. and Scott, A., 2015. *Australia's future workforce?* Committee for Economic Development of Australia, Melbourne. Available at: http://adminpanel.ceda.com.au/FOLDERS/Service/Files/Documents/26792~Futureworkforce_June2015.pdf

Gregg, P. and Gardiner, L., 2015. 'A steady job? The UK's record on labour market security and stability since the millennium'. The Resolution Foundation. Available at: http://www.resolutionfoundation.org/wp-content/uploads/2015/07/A-steady-job.pdf

Groom, B. and Powley, T., 2014. 'Reshoring driven by quality, not costs, say UK manufacturers'. Financial Times. Retrieved 6 June 2016 from: http://www.ft.com/cms/s/0/9757ffcc-9fc9-11e3-94f3-00144feab7de.html#axzz4G677KTDG

Hajkowicz, S., Reeson, A., Rudd, L., Bratanova, A., Hodgers, L., Mason, C. and Boughen, N., 2016. *Tomorrow's digitally enhanced workforce — Megatrends and scenarios for jobs and employment in Australia over the coming twenty years*. Commonwealth Scientific and Industrial Research

Organisation. Available at: http://www.csiro.au/~/media/D61/Files/16-0026_DATA61_REPORT_TomorrowsDigiallyEnabledWorkforce_WEB_160204.pdf?la=en

Haldane, A.G., 2015. 'Labour's share'. Available at: http://www.bankofengland.co.uk/publications/Pages/speeches/2015/864.aspx

Hartnett, M., Hodess, B., Hanson, M.S., Blanch, F., Nahal, S. and Roche, G., 2015. ,Thematic investing: Creative disruption'. Merrill Lynch, Pierce, Fenner & Smith Incorporated. Available at: http://www.bofaml.com/content/dam/boamlimages/documents/articles/D3_006/11511357.pdf

Head, S., 2014. *Mindless: Why smarter machines are making dumber humans*. Basic Books, New York.

Hesseling, J.K. and Goudswaard, A., 2013. 'Working time'. Available at: https://oshwiki.eu/wiki/Working_time

Horton, R., 2015. 'The robots are coming — A Deloitte insight report'. Deloitte LLP. Available at: http://www2.deloitte.com/content/dam/Deloitte/uk/Documents/finance/deloitte-uk-finance-robots-are-coming.pdf

House of Commons Science and Technology Committee, 2016. 'The big data dilemma fourth report of session 2015-16'. House of Commons Science and Technology Committee. Available at: http://www.publications.parliament.uk/pa/cm201516/cmselect/cmsctech/468/468.pdf

Health and Safety Laboratory Human Science Group, 2012. 'Collision and injury criteria when working with collaborative robots'. Health and Safety Executive Research Report RR906. Available at: http://www.hse.gov.uk/research/rrhtm/rr906.htm

Humphries, M., 2014. 'Amazon triples warehouse picker productivity with an army of robots'. Geek, 21 November 2014. Retrieved 5 June 2016 from: http://www.geek.com/news/amazon-triples-warehouse-picker-productivity-with-an-army-of-robots-1610088/

IARC (International Agency for Research on Cancer), 2010. *Shiftwork*. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Available at: http://monographs.iarc.fr/ENG/Monographs/vol98/mono98-8.pdf

IBM, 2016. 'What is Watson?' IBM. Retrieved 11 April 2016 from: http://www.ibm.com/smarterplanet/us/en/ibmwatson/what-is-watson.html

ICS, 2013. 'ICS — Guide to freelancers'. Available at: http://www.icsuk.com/ics-guide-to-freelancers/

ILO (International Labour Organisation), 2015a. 'Re-shoring in Europe: Trends and policy issues'. ILO Research Department Briefing. Available at: http://www.ilo.org/wcmsp5/groups/public/---europe/---ro-geneva/---ilo-brussels/documents/genericdocument/wcms_408974.pdf

ILO (International Labour Organisation), 2015b. 'World employment and social outlook: The changing nature of jobs'. Available at: http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_368640.pdf

ILO (International Labour Organisation), 2016. 'The future of work'. Available at: http://www.ilo.org/global/topics/future-of-work/lang--en/index.htm

IndustriALL European Trade Union, 2015. 'Digitising manufacturing whilst ensuring equality, participation and cooperation'. Policy brief. Available at: http://www.industriall-europe.eu/Committees/IP/PolBrief/PolicyBrief_2015-07_DigitisationOfManufacturing-EN.pdf

Insall, J. and Borthakur, A., 2015. 'From brawn to brains: The impact of technology on jobs in the UK'. Deloitte LLP. Available at: http://www2.deloitte.com/content/dam/Deloitte/uk/Documents/Growth/deloitte-uk-insights-from-brawns-to-brain.pdf

Institution of Mechanical Engineers, 2009. 'Geo-engineering: Giving us the time to act?' Institution of Mechanical Engineers, 2 November 2009. Available at: https://www.imeche.org/policy-and-press/reports/detail/geo-engineering-giving-us-the-time-to-act

International Cyber Security Protection Alliance (ICSPA) and the European Cybercrime Centre (EC3), 2012. 'Project 2020: Scenarios for the future of cybercrime — white paper for decision makers'.

Available at: https://www.icspa.org/wp-content/uploads/2014/12/ICSPA_Project_2020_-_Scenarios_for_the_Future_of_Cybercrime.pdf

Irving, M., 2016. 'Netherlands rolls out world-first nationwide Internet of Things network'. New Atlas, 1 July 2016. Retrieved 15 July 2016 from: http://www.gizmag.com/netherlands-nationwide-iot-network/44134/

Islam, I., 2016. 'Technology and the future of work in advanced economies'. Social Europe, 23 April 2015. Available at: https://www.socialeurope.eu/2015/04/technology-and-the-future-of-work-in-advanced-economies/

Jain, A. and Hassard, J., 2104. 'Precarious work: Definitions, workers affected and OSH consequences'. Available at: https://oshwiki.eu/wiki/Precarious_work:_definitions,_workers_affected_and_OSH_consequences

KPMG, 2013. 'Future state 2030: Global megatrends shaping government'. Available at: https://www.kpmg.com/ID/en/IssuesAndInsights/ArticlesPublications/Documents/Future-State-2030.pdf

Leopold, T. A., Ratcheva, V. and Zahidi, S., 2016. Global Challenge insight report. *The future of jobs — Employment, skills and workforce strategy for the fourth industrial revolution*. World Economic Forum, Geneva. Available at: http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf

Lister, K., 2016. 'Latest telecommuting statistics'. Retrieved 11 April 2016 from: http://globalworkplaceanalytics.com/telecommuting-statistics

Maciejewski, M. and Dimova, M., 2016. Fact sheets on the European Union — The ubiquitous digital single market. Available at: http://www.europarl.europa.eu/atyourservice/en/displayFtu.html?ftuId=FTU_5.9.4.html

Maciejewski, M., Isabel, N., Fisher, C. and Roginska, Y., 2014. Streaming and online access to content and services'. Study for the IMCO Committee, European Parliament, Brussels. Available at: http://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/492435/IPOL-IMCO_ET(2014)492435_EN.pdf

Maciejewski, M. and Marschall, B., 2016. 'Fact Sheets on the European Union — A digital agenda for Europe'. Available at: http://www.europarl.europa.eu/atyourservice/en/displayFtu.html?ftuId=FTU_5.9.3.html

Mahidhar, V. and Schatsky, D., 2013. 'The future of knowledge work: Signals for strategists'. Deloitte LLP. Available at: http://dupress.com/articles/the-future-of-knowledge-work/

Management Today, 2016. 'Welcome to the future of work'. Retrieved 11 May 2016 from: http://www.managementtoday.co.uk/futureofwork

Mandl, I., Curtarelli, M., Riso, S., Vargas, O. and Gerogiannis, E., 2015. *New forms of employment*. Eurofound. Available at: http://www.eurofound.europa.eu/sites/default/files/ef_publication/field_ef_document/ef1461en.pdf

Manyika, J., Chui, M., Bughin, J., Dobbs, R., Bisson, P. and Marrs, A., 2013. 'Disruptive technologies: Advances that will transform life, business, and the global economy'. McKinsey Global Institute. Available at: http://stratresearch.se/wp-content/uploads/mgi_disruptive_technologies_executive_summary_may2013.pdf

Markets and Markets, 2016. '3D printing market worth 30.19 billion USD by 2022'. Retrieved 20 May 2016: http://www.marketsandmarkets.com/PressReleases/3d-printing.asp

Marsh, A., du Preez, C.A., Shaw, D.S. and Zichermann, G., 2015. 'Future of work'. Raconteur Media. Retrieved 20 May 2016: https://raconteur.uberflip.com/i/611565-future-of-work

Massachusetts Institute of Technology Center for Digital Business, 2013. 'Digital leadership — An interview with Erik Brynjolfsson and Andrew McAfee — The second machine age: An industrial revolution powered by digital technologies'. Capgemini Consulting. Available at: https://www.uk.capgemini.com/resource-file-access/resource/pdf/second_machine_age_09_01_2013_0.pdf

Mauri, R., 2015. 'A new generation of data requires next-generation systems'. Retrieved 11 April 2016 from: http://www.wired.com/insights/2015/01/a-new-generation-of-data-requires-next-generation-systems/

McAlpine, K.J., 2016. '4D-printed structure changes shape when placed in water'. Harvard Gazette, 25 January 2016. Retrieved 11 April 2016 from: http://news.harvard.edu/gazette/story/2016/01/4d-printed-structure-changes-shape-when-placed-in-water/

Mettling, B., 2015. [Digital transformation and work life]. Available at: http://www.ladocumentationfrancaise.fr/var/storage/rapports-publics/154000646.pdf

Ministry of Defence UK, 2014. *Global strategic trends — Out to 2045*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/348164/20140821_DCDC_GST_5_Web_Secured.pdf

Misuraca, G., Broster, D., Centeno, C., Punie, Y., Lampathaki, F., Charalabidis, Y., Askounis, D., Osimo, D., Szkuta, K. and Bicking, M., 2010. *Envisioning digital Europe 2030: Scenarios for ICT in future governance and policy modelling*. Joint Research Centre of the European Commission. Available at: http://ftp.jrc.es/EURdoc/JRC61593.pdf

Morris, N., 2015. 'Three million Britons are working night shifts — And endangering their health'. Independent, 4 August 2015. Retrieved 11 April 2016, from: http://www.independent.co.uk/life-style/health-and-families/health-news/three-million-britons-working-night-shifts-and-endangering-their-health-10438592.html

Mott, N., 2016. 'Edward Snowden designs phone case to show when data is being monitored'. *The Guardian*, 22 July 2016. Retrieved 22 July 2016 from: https://www.theguardian.com/us-news/2016/jul/21/phone-case-privacy-data-monitor-bluetooth-wifi-snowden-introspection-engine

Mulligan, C., 2014. 'ICT and the future of transport: Part 2/8 industry transformation — Horizon scan'. Ericsson Networked Society Lab and Imperial College Business School. Available at: http://www.ericsson.com/res/docs/2014/ict-and-the-future-of-transport.pdf

Murphy, S.V. and Atala, A., 2014. '3D bioprinting of tissues and organs'. *Nature Biotechnology*, 32: 773-785. Available at: http://www.nature.com/nbt/journal/v32/n8/full/nbt.2958.html

Nati, M., 2016. 'IoT interoperability: challenges and opportunities'. Retrieved 14 July 2016 from: https://www.digitalcatapultcentre.org.uk/iot-interoperability-challenges-opportunities/

O'Collins, P., 2014. 'What is COSME and how can SMEs benefit from its €2.3 billion business support programme?' Business West, 8 July 2014. Retrieved 18 May 2016 from: http://www.businesswest.co.uk/blog/2014/07/08/what-is-cosme-and-how-can-sme-s-benefit-from-its-2-3-billion-business-support-programme

Pannone LLP, 2013. 'Zero hours contracts'. Retrieved 11 April 2016 from: http://www.pannone.com/media-centre/articles/employment-employment-articles/zero-hour-contracts

PEROSH (Partnership for European Research in Occupational Safety and Health), 2014. 'Concept of integration of ambient intelligence solutions for safety and health towards smart factories'. Retrieved 9 May 2016 from: http://www.perosh.eu/research-projects/perosh-projects/concept-of-integration-of-ambient-intelligence-solutions-for-safety-and-health-towards-smart-factories/

Pofeldt, E., 2015. 'Intuit: On-demand workers will more than double by 2020'. Forbes, 13 August 2015. Retrieved 11 April 2016 from: http://www.forbes.com/sites/elainepofeldt/2015/08/13/intuit-on-demand-workers-will-more-than-double-by-2020/#c28785b679dd.

Pym, H., 2014. 'Why companies are 're-shoring' back to Britain'. BBC News, 17 February 2014. Retrieved 6 June 2016 from: http://www.bbc.co.uk/news/business-26235707

Raconteur, 2016. 'The future office'. Retrieved 6 May 2016 from: http://raconteur.net/infographics/the-future-office

Rendell, M. and Brown, J., 2014. 'The future of work: A journey to 2022'. Available at: https://www.pwc.com/gx/en/managing-tomorrows-people/future-of-work/assets/pdf/future-of-rork-report-v16-web.pdf

RRAC (Risk and Regulation Advisory Council), 2009. 'A practical guide to public risk communication. The five essentials of good practice'. Retrieved 6 May 2016 from: http://webarchive.nationalarchives.gov.uk/20090609003228/http://www.berr.gov.uk/deliverypartners/list/rrac/index.html

Robert Half, R., 2015. 'Get ready for generation Z'. Available at: https://www.roberthalf.com/sites/default/files/Media_Root/images/rh-pdfs/rh_0715_wp_genz_nam_eng_sec.pdf

Roberts, C., 2016. 'Start me up: Why London needs open workspaces for creativity, innovation and growth'. Institute for Public Policy Research. Available at: http://www.ippr.org/files/publications/pdf/start-me-up_March2016.pdf?noredirect=1

Royal Academy of Engineering and the Institution of Engineering and Technology, 2015. 'Connecting data driving productivity and innovation'. Royal Academy of Engineering. Available at: http://www.raeng.org.uk/publications/reports/connecting-data-driving-productivity

Rushton, L., Hutchings, S.J., Fortunato, L., Young, C., Evans, G.S., Brown, T., Bevan, R., Slack, R., Holmes, P., Bagga, S., Cherrie, J.W. and Van Tongeren, M., 2012. 'Occupational cancer burden in Great Britain'. *British Journal of Cancer,* 107(Suppl. 1): S3-7. Available at: http://www.ncbi.nlm.nih.gov/pubmed/22710676

SAMI Consulting, 2015. 'Horizon scanning project for Defra and partners — "Strategic evidence of future change" and executive summaries'. SAMI Consulting. Available at: http://www.samiconsulting.co.uk/5reports.php

Sample, I., 2016. 'AI will create "useless class" of human, predicts bestselling historian'. *The Guardian*, 20 May 2016. Retrieved 25 May 2016 from: https://www.theguardian.com/technology/2016/may/20/silicon-assassins-condemn-humans-life-useless-artificial-intelligence

Schofield, H., 2016. 'The plan to ban work emails out of hours'. BBC News, 11 May 2016. Retrieved 25 May 2016 from: http://www.bbc.co.uk/news/magazine-36249647

Schwab, K. 2016. *The fourth industrial revolution*. World Economic Forum, Geneva.

SHARE (Survey of Health, Aging and Retirement in Europe). 'Share — Survey of Health, Ageing and Retirement in Europe'. Available at: http://www.share-project.org/fileadmin/SHARE_Brochure/share_broschuere_web_final.pdf

Sharp, A., Elliott, S., Prince, D., O'Grady, F., Clews, S., Purva, M. and Dix, G., 2016. 'Workplace trends 2016'. The Advisory, Conciliation and Arbitration Service (ACAS). Available at: http://www.acas.org.uk/media/pdf/l/4/Workplace_trends_of_2016.pdf

Slack, R., Young, C. and Rushton, L., 2012. 'Occupational cancer in Britain: Female cancers: breast, cervix and ovary'. British Journal of Cancer, 107(Suppl. 1): S27-32. Available at: http://www.ncbi.nlm.nih.gov/pubmed/22710675

Steel, M., 2011. 'Changes in shift work patterns over the last ten years (1999 to 2009)'. Health and Safety Executive and Office for National Statistics. Available at: http://www.hse.gov.uk/research/rrpdf/rr887.pdf

Stella, R., 2016. 'Scientists unveil new '4D-printing' technique that produces shape shifting objects'. Digital Trends, 2 February 2016. Retrieved 25 May 2016 from: http://www.digitaltrends.com/cool-tech/harvard-scientists-unveil-4d-printing/

Stewart, I., De, D. and Cole, A., 2015. 'Technology and people: The great job-creating machine'. Deloitte LLP. Available at: http://www2.deloitte.com/content/dam/Deloitte/uk/Documents/finance/deloitte-uk-technology-and-people.pdf

Stylianou, N., Nurse, T., Fletcher, G., Fewster, A., Bangay, R. and Walton, J., 2015. 'Will a robot take your job?' BCC News, 11 September 2015. Retrieved 25 May 2016 from: http://www.bbc.co.uk/news/technology-34066941

SUVA, 2011. 'Prospective 2029: Etude sur les futurs risques d'accidents et de maladies professionnelles et les opportunités de prévention'. Suva, Lucerne.

Swiss Federal Institute of Technology Zurich, 2016. 'KOF index of globalization'. Retrieved 25 May 2016 from: http://globalization.kof.ethz.ch/

Terrorism Research, 2016. 'Future trends in terrorism'. Available at: http://www.terrorism-research.com/future/

The European Truck Platooning Challenge, 2016. 'What is truck platooning?' Retrieved 25 May 2016 from: https://www.eutruckplatooning.com/About/default.aspx

Thielman, S., 2016. 'Amazon moves one step closer toward army of warehouse robots'. *The Guardian*, 5 July 2016. Retrieved 29 July 2016 from: https://www.theguardian.com/technology/2016/jul/05/amazon-robotics-competition-dutch-team-first-prize

Thorley, C., 2016. 'Technological advances both threaten our mental health and give us means to improve it'. Retrieved 15 April 2016 from: http://www.ippr.org/blog/technological-advances-both-threaten-our-mental-health-and-give-us-means-to-improve-it?utm_source=IPPR+weekly+newsletter&utm_campaign=4f024948c7-IPPR-news_160415_Scot-tax-props_EUmig-opts_MH%2Btech&utm_medium=email&utm_term=0_0b30c067fe-4f024948c7-277559633

Toft, S., 2014. 'CIPD Question Time — the future of work debate'. Personnel Today, 19 March 2014. . Retrieved 15 April 2016 from: http://www.personneltoday.com/hr/cipd-question-time-future-work-debate/

Townsend, T., 2015. 'Study says work force shifting increasingly toward freelance'. . Retrieved 15 April 2016 from: http://www.inc.com/tess-townsend/workforce-increasingly-freelance-says-study.html

United Nations, 2015. *World population prospects: The 2015 revision, key findings and advance tables*. Available at: http://esa.un.org/unpd/wpp/publications/files/key_findings_wpp_2015.pdf

University of Waterloo, 2015. 'What should we do about globalisation?'. Retrieved 15 April 2016 from: https://impactofinformationsystemsonsociety.wordpress.com/2015/01/18/what-should-we-do-about-globalisation/

Vyas, M.V., Garg, A.X., Iansavichus, A.V., Costella, J., Donner, A., Laugsand, L.E., Janszky, I., Mrkobrada, M., Parraga, G. and Hackam, D.G., 2012. 'Shift work and vascular events: Systematic review and meta-analysis'. *British Medical Journal,* 345: e4800. Available at: http://www.bmj.com/content/345/bmj.e4800

Wakefield, J., 2016. 'Tomorrow's buildings: Construction industry goes robotic'. BBC News, 4 May 2016. . Retrieved 9 May 2016 from: http://www.bbc.co.uk/news/technology-35746648

Walport, M., Sir, 2016. *Distributed ledger technology: Beyond block chain*. Government Office for Science. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492972/gs-16-1-distributed-ledger-technology.pdf

Walters, D. and Wadsworth, E., 2014. 'Contexts and determinants of the management of occupational safety and health in European workplaces'. *Policy and Practice in Health and Safety,* 12(2): 109-130. Available at: http://www.tandfonline.com/doi/abs/10.1080/14774003.2014.11667806

Ward, M., 2016. 'Could hackers turn the lights out?' BBC News, 16 March 2016. Retrieved 9 May 2016 from: http://www.bbc.co.uk/news/technology-35204921

Wearden, G., 2016. 'Davos 2016: Eight key themes for the World Economic Forum'. *The Guardian*, 19 January 2016. Retrieved 9 May 2016 from:

https://www.theguardian.com/business/2016/jan/19/world-economic-forum-davos-2016-eight-key-themes-robotics-migration-markets-climate-change-europe-medicine-inequality-cybercrime

Williams, Z., 2016. 'If robots are the future of work, where do humans fit in?' *The Guardian*, 24 May 2016. Retrieved 9 May 2016 from: http://www.theguardian.com/commentisfree/2016/may/24/robots-future-work-humans-jobs-leisure

Wilson, J., 2012. 'Your smartphone is a pain in the neck'. CNN, 20 September 2012. Retrieved 9 May 2016 from: http://edition.cnn.com/2012/09/20/health/mobile-society-neck-pain/

World Economic Forum, 2016. 'Top 10 Emerging Technologies of 2016'. Available at: http://www3.weforum.org/docs/GAC16_Top10_Emerging_Technologies_2016_report.pdf

Wright, I., 2016. 'Sports Direct workers aren't the only ones unprotected in our "gig economy"'. *The Guardian*, 22 July 2016. Retrieved 22 July 2016 from: https://www.theguardian.com/commentisfree/2016/jul/21/gig-economy-workers-sports-direct

9 Glossary

24/7 — 24 hours a day, 7 days a week, that is, continuously.
3D printing — a process for making a physical object from a three-dimensional digital model, typically by laying down many successive thin layers of a material, also known as additive manufacturing.
3D bio-printing — 3D printing of biocompatible cells and materials into functional living tissues, including bone, heart tissue and multilayered skin that can be transplanted.
4D printing — 3D printing with time as a fourth dimension, so that the produced object can change form over time in response to a change in environment.
5G — 5th generation mobile networks, providing increased internet connection speeds compared with current 4G networks.
Airbnb — community marketplace founded in 2008 for people to list accommodation to let (principally their own homes) and to find and book accommodation around the world.
AM — additive manufacturing: a process for making a physical object from a three-dimensional digital model, typically by laying down many successive thin layers of a material, also known as 3D printing.
AmI — ambient intelligence: technology embedded in an environment that senses and responds to the presence of people.
AI — artificial intelligence: a machine intelligence that acts as a rational agent, perceiving and responding flexibly to environmental cues to achieve a defined goal or defined goals.
AR — augmented reality, where real-world views are overlaid with contextual information, usually via a display that is sometimes worn over the eyes.
Auxetics — a new class of materials that expand when stretched.
AV — autonomous (or self-driving) vehicle.
Baby boomers — broadly understood as referring to individuals born in the period after the Second World War, between 1946 and 1964, when there was a marked increase in birth rates.
Bandwidth — refers to the amount of information that can be carried by a signal.
Big Data — the potential of new technologies to produce data sets so large and complex that entirely new data processing applications are needed to capture and analyse them.
Biomimetics — the imitation of the models, systems, and elements of nature.
Blockchain — a distributed database that maintains a continuously growing list of data records hardened against tampering and revision.
BRIC — a collective term for the countries of Brazil, Russia, India and China, which are currently the fastest-growing economies and emerging markets in the world.
Bridge employment — paid work taken on after someone has retired or started receiving a pension.
BYOD — Bring Your Own Device — when employees use their own devices (e.g. smart-phones or tablets) in the workplace.

Burnout — a type of psychological stress: occupational burnout or job burnout is characterised by exhaustion, lack of enthusiasm and motivation, and feelings of ineffectiveness, and may also have the dimension of frustration or cynicism, resulting in reduced efficacy in the workplace.
Click-and-collect — buy something online then collect it in store or at another convenient location.
Cloud (the) — a computing paradigm that provides shared processing resources and data on demand via the internet.
Cloud technology — allows users to store, process and share data using third-party data centres.
CO_2 — carbon dioxide.
Crowd-funding — a way of raising finance by asking a large number of people each for a small amount of money in return for equity, repayment with interest later, acknowledgement and/or one of the finished products.
Crowd-working — where an online platform is used to enable organisations or individuals to access an indefinite and unknown group of other organisations or individuals to solve specific problems or to provide specific services or products in exchange for payment.
Cyberbullying — where individuals are bullied through social media.
Dematerialised consumption — the reduction in the quantity of raw materials required to serve economic functions (doing more with less).
DESI — Digital Economy and Society Index, a composite index that summarises relevant indicators on Europe's digital performance and tracks the evolution of EU Member States in digital competitiveness. These indicators include broadband speed, affordability (mobile and fixed), skills, online communications and transactions, integration of technology into business and prevalence of digital public services.
Digital Taylorism — where tasks are standardised by the use of IT, refining the tools and techniques employed to improve efficiency and enable intensive monitoring, often through automated management.
Digital whip — new forms of discipline and control established by the use of ICT, whereby workers' schedules are set and monitored by a computer, often with an embedded continuous improvement algorithm based on the average speed at which workers are to complete specific tasks.
Ebay — multinational corporation and e-commerce company, providing consumer-to-consumer and business-to-consumer sales services via the internet.
EC — European Commission, the executive body of the EU responsible for proposing legislation, implementing decisions, upholding the EU treaties and managing the day-to-day business of the EU.
e-commerce — selling and buying online/over the internet.
Electromagnetic spectrum — the collective term for all possible frequencies of electromagnetic radiation, from lower than radio waves through visible light to gamma rays.
EMF — electromagnetic field: a physical field produced by electrically charged objects that affects the behaviour of charged objects in its vicinity.
Emerging risk — one that is both new **and** increasing.

Etsy — peer-to-peer e-commerce website focused on handmade or vintage items and supplies, as well as unique factory-manufactured items.
EU — European Union, a politico-economic union of 28 Member States that are located primarily in Europe.
EU-OSHA — European Agency for Safety and Health at Work.
Europe 2020 — the EU's ten-year jobs and growth strategy.
Facebook — an online social networking tool.
Graphene — a two-dimensional atomic scale structural modification of carbon that forms a honeycomb lattice in which each atom forms a vertex.
Generation X, Y, Z, etc. — successive generations following after the 'baby boomers'; although definitions differ, broadly Generation X were born between the early 1960s and early 1980s, Generation Y or 'millennials' between the early 1980s and 2000s, and, variously, the inception of Generation Z is placed between the early 1990s and the early 2000s.
Geoengineering —deliberate large-scale intervention in the Earth's natural systems to counteract climate change.
Green energy — energy derived from renewable resources such as tidal energy, wind energy or solar power.
HGV — heavy goods vehicle.
HIVE — Hyper Interaction Viability Experiments (EU programme)
HMD — head-mounted displays.
HR — human resources.
ICT — information and communication technologies: technologies and software that enable users to access, store, transmit, and manipulate information.
ICT-ETs — ICT-enabled technologies.
Increasing risk — one where the number of hazards leading to the risk is growing; **or** the likelihood of exposure to the hazard leading to the risk is increasing (exposure level and/or the number of people exposed; **or** the effect of the hazard on workers' health is getting worse (seriousness of health effects and/or the number of people affected).
Indigogo — largest global website for fundraisers, which helps individuals, groups and non-profits raise money online to make their ideas a reality through crowd-funding.
IoT — the Internet of Things: the network of physical objects — devices, vehicles, buildings and other items — embedded with electronics, software, sensors and network connectivity that enables these objects to collect and exchange data.
IP — intellectual property: creations of the intellect (e.g. inventions; literary and artistic works; designs; and symbols, names and images used in commerce) for which a monopoly is assigned to designated owners by law.

IPv6 — Internet Protocol version 6 is the most recent version of the communications protocol that provides an identification and location system for computers on networks and routes traffic across the internet. IPv6 was developed by the Internet Engineering Task Force (IETF) to deal with the long-anticipated problem of IPv4 address exhaustion.
IT — information technology: the application of computers to store, retrieve, transmit and manipulate data.
Job for life — a secure career from early in working life right through until retirement.
Job mortgage — a loan to allow an individual to access training or achieve professional development, based on projected future income.
Kickstarter — an American public-benefit corporation that has built a global crowd-funding platform with the mission of helping bring creative projects to life.
KOF Index — a measure of globalisation.
M2M — machine-to-machine communication: takes place increasingly but not necessarily over the internet.
Micro-enterprise — one that has fewer than ten employees and an annual turnover or balance sheet total that does not exceed EUR 2 million.
MINT countries — an acronym referring to the economies of Mexico, Indonesia, Nigeria and Turkey.
MOOC — massive open online course: an online course aimed at unlimited participation and open access via the internet.
Moore's Law — the observed phenomenon whereby the number of transistors on computer processors doubles every two years.
MSD — musculoskeletal disorder: injuries or pain in the joints, ligaments, muscles, nerves or tendons that support the limbs, neck and back.
Nanotechnology — involves the manipulation of matter at a level of magnitude between 1 to 100 nanometres (1 nanometre = 1 billionth of a metre).
New risk — one that did not previously exist and is caused by new processes, new technologies, new types of workplace, or social or organisational change; **or** is a long-standing issue newly considered as a risk due to a change in social or public perceptions; **or** because new scientific knowledge allows a long-standing issue to be identified as a risk.
NO_X — generic term covering both nitric oxide and nitrogen dioxide.
Offshoring — the practice of basing some of a company's processes or services overseas to take advantage of lower costs.
OSH — occupational safety and health.
Outsourcing — obtaining goods or a service by contract from an outside supplier.
Pay-as-you-go — where a service provider charges for use as costs arise or in small periodic increments in advance.

Piezoelectric — ability of certain materials to generate an electric charge in response to applied mechanical stress.
Platooning — comprises a number of trucks equipped with state-of-the-art driving support systems, one closely following the other under the control of a lead truck. This forms a platoon, with the trucks driven by smart technology and mutually communicating.
Portfolio career — a working life where an individual works in a series of different types of job, or has several different jobs at the same time.
Quantum computing — the attempt to harness the indeterminacy and entanglement of particles at the quantum level to exponentially increase computing power.
Rare earth metal — a group of chemically similar metallic elements that are not especially rare but tend to occur together in nature and are difficult to separate from one another.
Remote-working — where an individual works remotely from the offices of their employer.
Reshoring — the process by which organisations move outsourced manufacturing closer to home, primarily due to concerns about rising costs of labour and/or transport or problems of quality control.
SDN — software-defined networking is an emerging computing network architecture that replaces the client-server model with one that makes network control directly programmable, enabling a dynamic traffic flow management to keep pace with the growing number of devices connecting to the internet.
Self-healing materials — materials designed, taking inspiration from the biological world, to be able to self-organise and self-repair.
Servitisation — the process of increasing the value of products by adding services or ultimately selling services instead of products.
Shapeways — e-commerce website selling 3D-printed products.
Sharing economy — a form of exchange where individuals share access to goods and services.
Skype — a computer application that is primarily used to allow people to speak to one another over the internet and also, if they wish, to see a real-time image of the person they are speaking to.
Smart grid — an electricity supply network that uses digital communications technology to detect and react to local changes in usage.
SMEs — small and medium-sized enterprises.
Social media — a large variety of computer-based tools that allow people or companies to create, share or exchange information, career interests, ideas and pictures/videos in virtual communities and networks; well-known examples are Facebook and LinkedIn.
STEEP — societal, technological, economic, environmental and political: taxonomy used for classifying drivers or trends of change in foresight studies.
STEM — science, technology, engineering and mathematics.
Talent cloud — web-based social networks for sharing work opportunities and matching would-be employers with employees for discrete tasks.

Tapered retirement — when employees gradually reduce their duties as they approach retirement, through part-time work or self-employment.
TaskRabbit — an online and app-based marketplace that matches freelance labour with local demand.
Technostress — negative psychological link between people and the introduction of new technologies.
Text-neck — neck pain and injury cause by sustained periods of looking down at smartphones, tablets and other mobile devices.
Tribology — the study of friction and lubricants.
Trillion — one million million, or 10^{12}.
Tripartite — involving representatives of government, workers and employers.
Tweets — messages of 140 characters or less sent to an online network of followers using Twitter.
Twitter — an online social networking service that allows users to post and read messages of up to 140 characters, or 'tweets'.
Uber — mobile app that allows consumers with smartphones to submit a trip request, which is then routed to drivers who use their own cars.
United Nations — an intergovernmental organisation that promotes international cooperation.
Veterans — people who continue to work past the age when they are entitled to receive a company and/or government pension.
VR — virtual reality, an immersive computer-simulated or multimedia-generated experience that can be multisensory and enables the participant to interact with the virtual environment.
Virtual workplaces — working online anywhere and any time, such that location is irrelevant.
WEF — World Economic Forum, a Swiss non-profit foundation with the purpose of fostering public-private cooperation in order to improve the state of the world by engaging business, political, academic and other leaders of society to shape global, regional and industry agendas.
WHO — World Health Organization, a specialised agency of the United Nations that is concerned with international public health.
WiFi — a wireless local area network (WLAN) using radio frequencies to allow devices such as personal computers, smartphones and peripherals within range to connect to the network and internet.

Appendix A: List of interviewees

Interviewees are listed in alphabetical order by surname.

Name	Affiliation
Jorge Costa-David	European Commission, Directorate-General EMPL.B.3, Employment, Social Affairs and Equal Opportunities, Health, Safety and Hygiene at Work. Member of EU-OSHA's former European Risk Observatory Advisory Group (EROAG)
Elsbeth de Korte	Manager of the Workplace Innovation and Design Research and Consultancy Team, Netherlands Organisation for Applied Scientific Research — Toegepast Natuurwetenschappelijk Onderzoek (TNO), The Netherlands
Magnus Falk	Work Environment Authority, Sweden
Dave Faulkner	Director, Climate Associates Limited, United Kingdom
Jean Gelissen	Leader of Health and Wellbeing, European Institute of Innovation and Technology (EIT) ICT Laboratories, Co-location Centre Eindhoven, The Netherlands
Nikolaos Kastrinos	Foresight Team Lead of the Directorate General for Research and Innovation of the European Commission
Viktor Kempa	Health and Safety Working Conditions Research Department, European Trade Union Institute (ETUI), Belgium Representative of the workers' group in EU-OSHA Prevention and Research Advisory Group
Risto Linturi	Chairman, R Linturi plc, Finland
Irene Lopez de Vallejo	Research and Development Director, Connected Digital Economy Catapult, United Kingdom
Ugo Pagallo	Professor of Jurisprudence, Faculty of Law, University of Turin, and Vice-President of the Italian Society on Legal Informatics, Italy
Geoff Pegman	Managing Director, RU Robots, United Kingdom
Daniel Podgórski	Deputy Director and International Affairs Coordinator, Central Institute for Labour Protection — National Research Institute (CIOP), Poland Member of EU-OSHA's Prevention and Research Advisory Group, representative of government group
Jan Popma	Senior researcher in Labour, Risks and Regulation, University of Amsterdam and Policy Advisor in Occupational Health and Safety to the Trade Union Confederation (FNV), The Netherlands
Frank Pot	Professor Emeritus of Social Innovation of Work and Employment, Leiden University, The Netherlands

Martin Röhrich	Project Leader, Confederation of Employers 'and Entrepreneurs' Associations (KZPS), Czech Republic Representative of the employer's group in EU-OSHA Prevention and Research Advisory Group
Philippe Saint Aubin	Federal secretary, Economic Social and Environmental Council and French Democratic Confederation of Labour (CFDT), France
Roger Upfold	Policy Advisor, Safety Unit, Health and Safety Executive (HSE), United Kingdom
Oscar Vargas	Research Officer, Working Conditions and Industrial Relations, Eurofound, Ireland
Greet Vermeylen	Senior Programme Manager, Working Conditions and Industrial Relations, Eurofound, Ireland

The two experts from Eurofound, Oscar Vargas and Greet Vermeylen, were interviewed together.

The following experts were also consulted to inform the horizon scanning (and Jim Norton also discussed the consultee briefing with a member of the project team):

Christophe Degryse	Senior researcher and assistant to the General Director, European Trade Union Institute (ETUI), Belgium
Jim Norton	Independent director, policy adviser and public speaker; visiting Professor of Electronic and Electrical Engineering, University of Sheffield; Chair of Serious Games International Limited; board member, Foundation for Information Policy Research (FIPR); external board member, Parliamentary Office of Science and Technology (POST), United Kingdom

Appendix B: Interview script

At the outset of the interview the participants will be reminded that:

- Their participation is voluntary and they can change their mind about participating at any point, including during the interview, or they can choose not to answer particular questions. The interview is expected to last 30 to 60 minutes
- Interview responses will remain confidential and unattributed, but names of participants will be acknowledged in the report. Exceptionally we may seek the interviewee's permission to attribute a particular quote.

Interviewers should:

- Avoid "leading the witness". It is useful to ask supplementary questions to draw out further evidence but not to "shape the evidence" for the respondent.
- Ask interviewees for their background, position, sector and their involvement/interest in ICT and work, and in OSH
- Inform the interviewee that we are interviewing them as an "expert" and we are not looking for their employer's views or policies.
- Interviews should begin with agreement on the topic and on the horizon of enquiry. For example using the following question

  "May we agree that our topic is **"Foresight of new and emerging occupational safety and health risks associated with information and communications technologies and work locations by 2025 and beyond?"**

- Outline definitions of "ICT, including AI and robotics" and "New and emerging risks" as given in the summary report previously provided.

1. Opening question

Having read the summary report of contextual drivers of change, what do you see as the main drivers in the report affecting new and emerging risks to occupational safety and health associated with information and communications technologies and work locations by 2025, and beyond? Please think about societal, technological, environmental and political (STEEP) drivers of change.

- Is there anything additional that was not in the literature review that you feel is a relevant driver?
- Are there any drivers that don't belong?
- Are there any drivers you disagree with?
- Which drivers are most likely to drive ICT-enabled technology?

If the respondent is overly focusing on just one part of the STEEP taxonomy gently remind them of the others.

2. Clairvoyant

If you could spend some time with someone who knew the outcome, a clairvoyant or oracle if such existed, what would you want to know? i.e. what are the critical issues?

3. An optimistic outcome

Optimistic but realistic. What would be a good outcome and what would be the signs?

Respondents may also introduce things that fit better under the next question, which is fine; capture it and then ask if they have anything else to add in terms of an optimistic outcome.

4. A pessimistic outcome

How could the environment change to make things more difficult? What could go wrong?

If respondents have already mentioned pessimistic outcomes whilst answering the previous questions acknowledge this and ask if there is anything else they would like to add.

5. Looking back

Looking back up to 20 years, what successes can we build on and what failures can we learn from?

Respondents may also introduce things that fit better under the next question, which is fine; capture it and then ask if they have anything else to add in terms of looking back.

6. Looking forward

What decisions need to be made in the near term to achieve the desired long-term outcome?

If respondents have already mentioned looking forwards whilst answering the previous questions acknowledge this and ask if there is anything else they would like to add in terms of looking forward.

7. The epitaph

If you had a mandate, without constraints, what would you want to do to achieve the best possible *outcome in relation to ICT-ET associated work? What would you want to be remembered for?

If the expert has an OSH background, or at this point has demonstrated an understanding of OSH, then insert OSH (in full or as an acronym as appropriate) before* ***outcome* *in the above question.*

- After the “epitaph” it is helpful to ask the respondent if he/she wishes to add any further thoughts. This may raise points which the interviewer may have missed in the flow of the interview.

The interview concludes with thanks to the respondent and an invitation to comment on the process.

Appendix C: More detailed results from interviews

The following figures show the number of comments made by interviewees that referenced something relating to each of the trends or drivers of change originally identified during the horizon scanning in Task 1. The lines labelled 'S?? — New information' in Figure C1 and 'T?? — New information' in Figure C2 show how many comments did not relate to existing societal or technological trends and drivers and which therefore added new information to the consolidated list of trends and drivers.

Figure C1: Number of times comments referenced something relating to each societal trend or driver

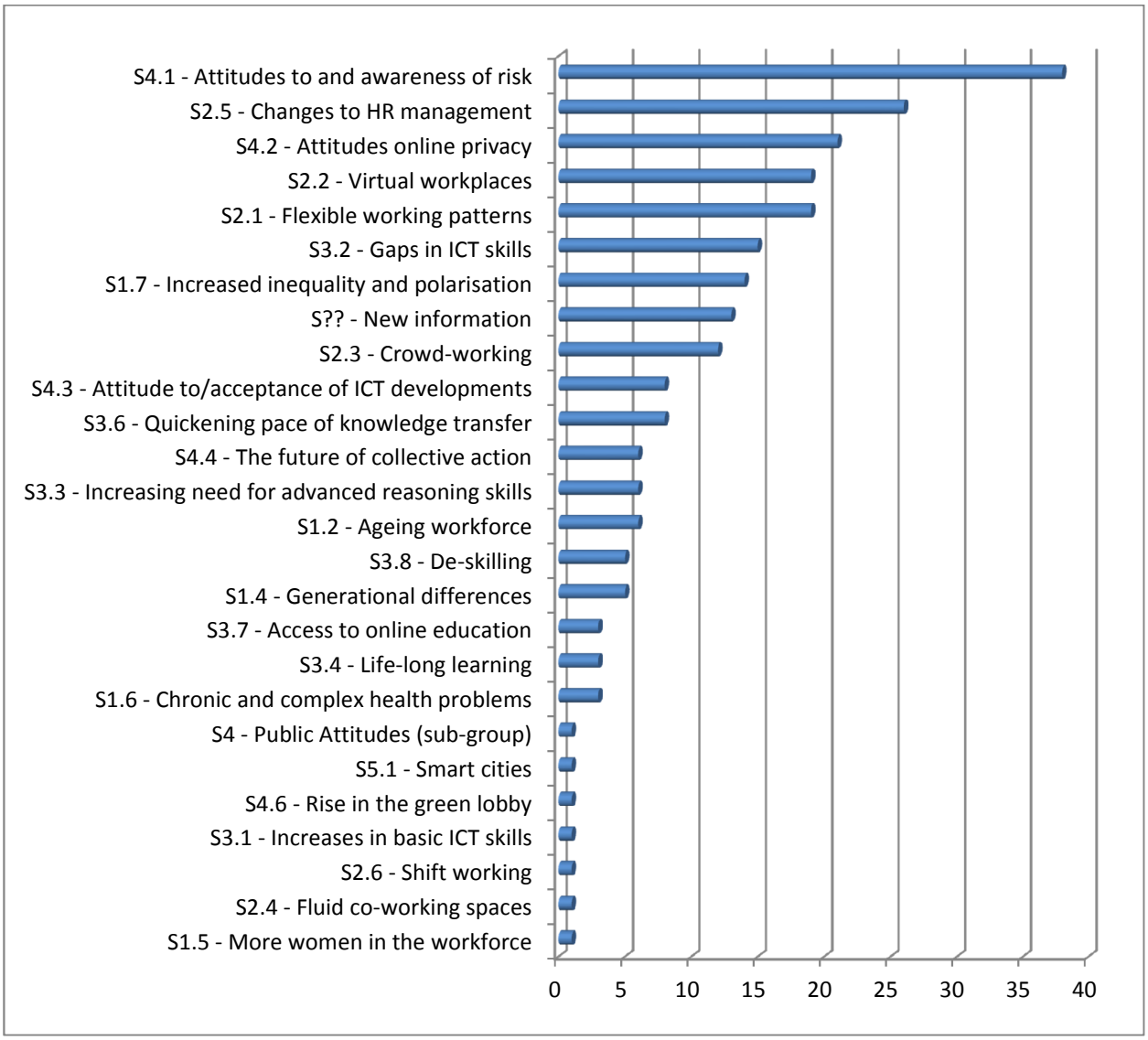


Figure C2: Number of times comments referenced something relating to each technological trend or driver

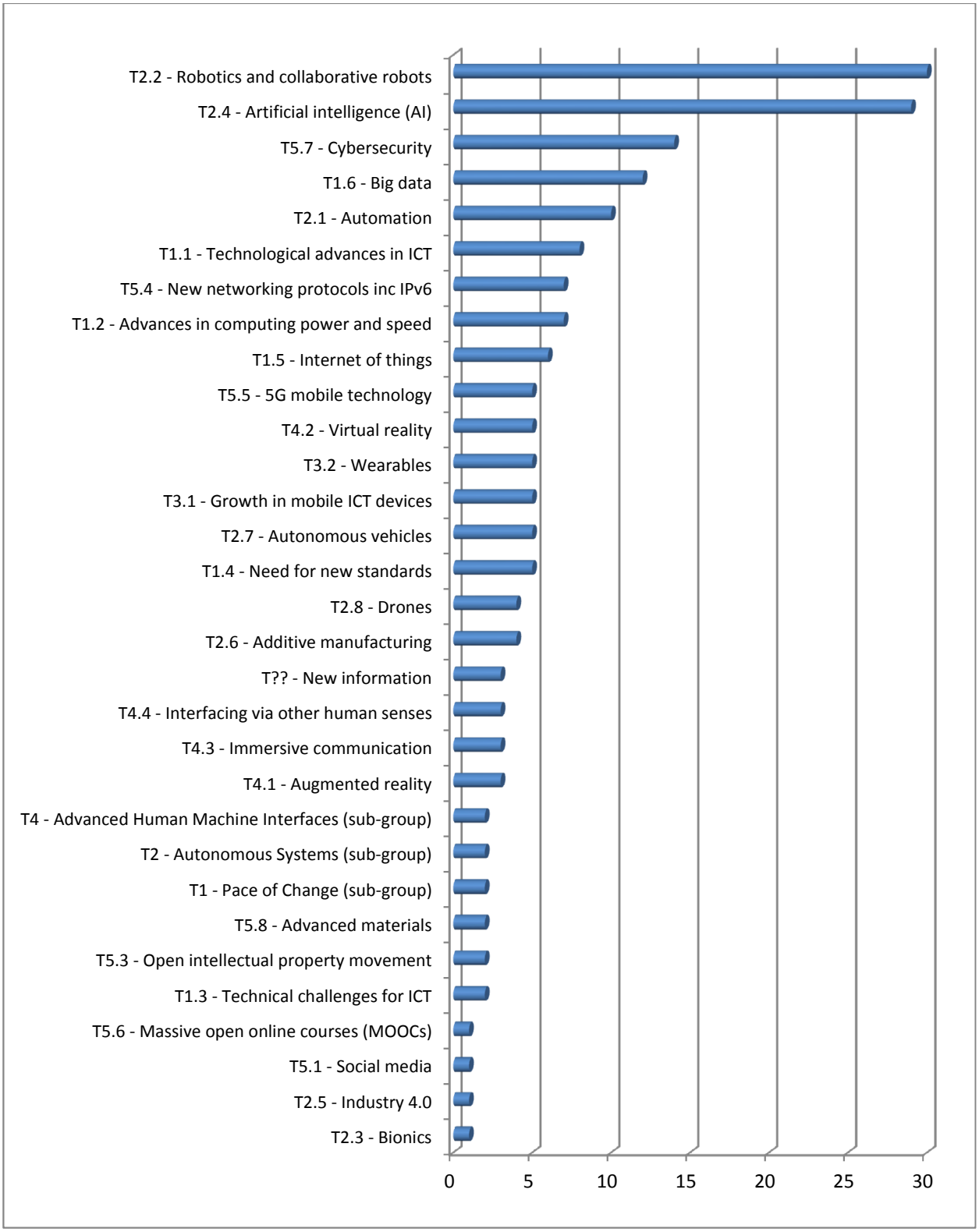


Figure C3: Number of times comments referenced something relating to each economic trend or driver

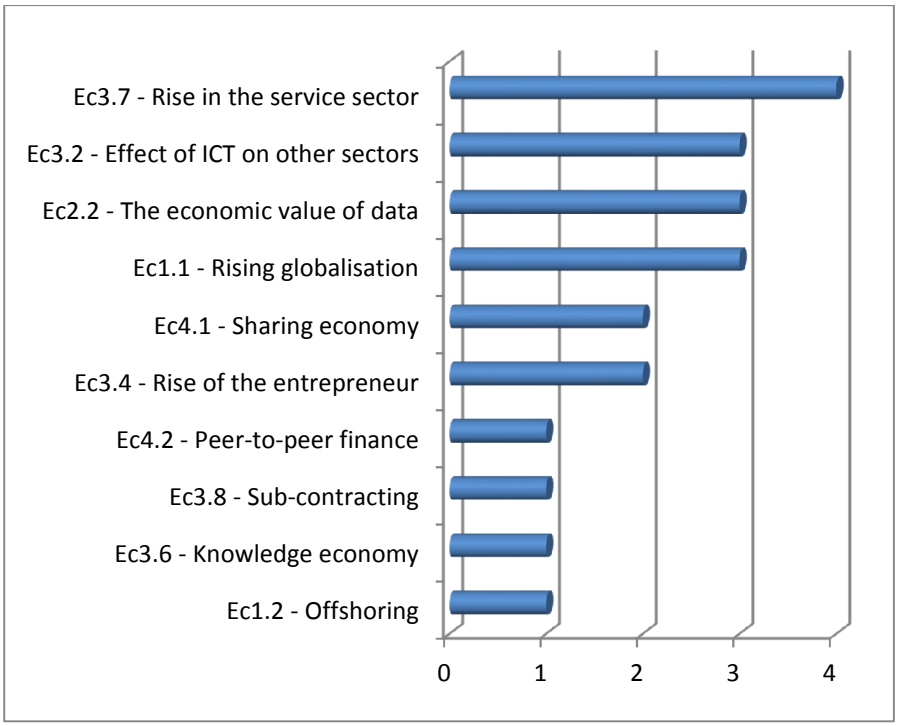


Figure C4: Number of times comments referenced something relating to each environmental trend or driver

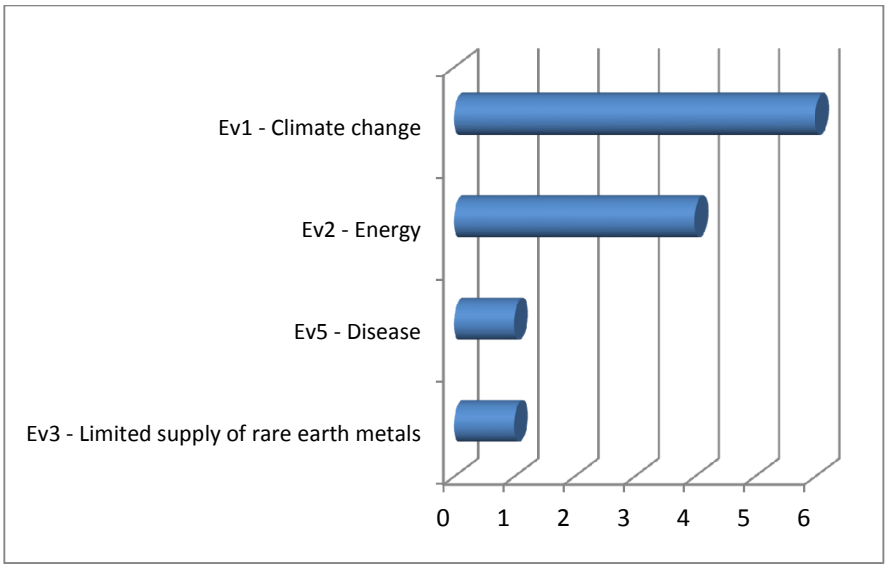
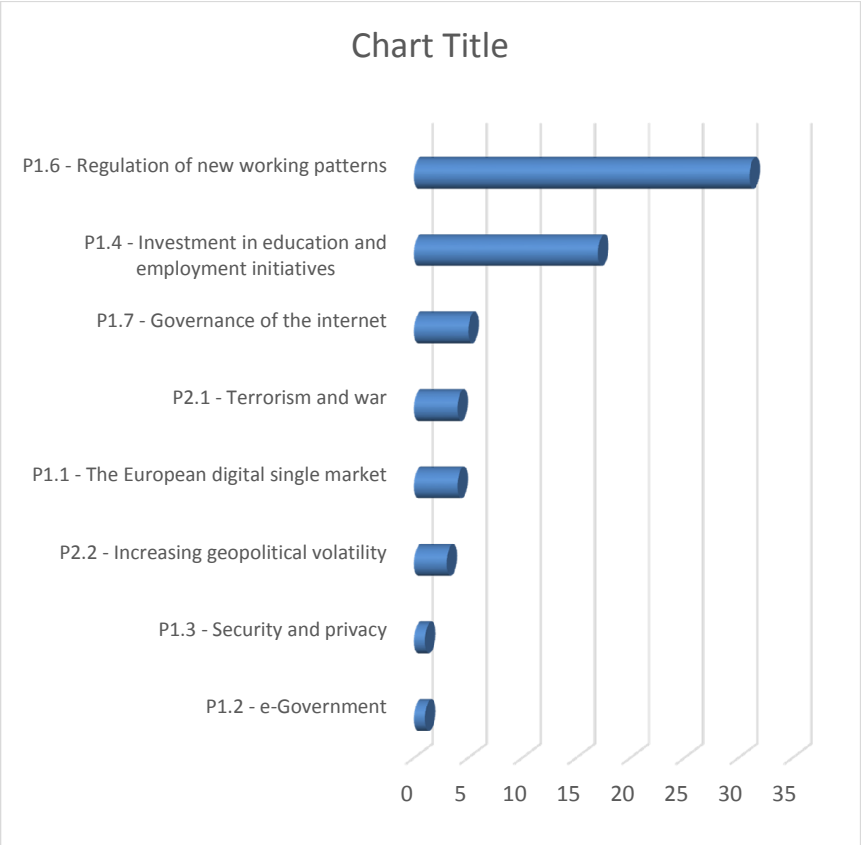


Figure C5: Number of times comments referenced something relating to each political trend or driver



Appendix D: Web survey content and question set

Dear Participant,

Welcome to EU-OSHA's survey on ICT, work location and OSH and thank you for your interest in the project.

This research is being carried out for the European Agency for Safety and Health at Work (EU-OSHA) by the UK Health and Safety Laboratory's (HSL) Foresight Centre, SAMI Consulting Limited and Futurizon Limited. The aim of the project is to produce a set of future scenarios to 2025 to consider the potential impacts that developments in information and communication technologies (ICT) and changes in work location, may have on workers' safety and health. These scenarios will be used to inform EU decision makers, Member States' Governments, trade unions and employers, so that they can take decisions to shape the future of occupational safety and health (OSH) towards safer and healthier workplaces.

An overview of the project is available here

Additionally, a briefing document for participants, giving more detailed information about the trends and drivers, is available here.

Part of the process of developing scenarios is the identification of trends and drivers of change that will influence health and safety in relation to ICT developments.

The trends and drivers of change presented below have been identified by the project team via a search of literature and phone interviews. You are invited to give your views on which are the most important trends and drivers of change in the context of the project and to offer your suggestions for anything we might have missed.

Taking part in this research is entirely voluntary. You may withdraw from the research at any time without giving a reason. You do not have to answer any questions that you do not want to. The information given is both confidential and anonymised and will be considered as part of a group, not an individual response.

In this Web Consultation Exercise we are looking *for trends and drivers of change*, not just for ICT developments, but also for *health and safety implications* of new ICT technologies and work location.

If you have any questions or would like further information on this project, please contact: HSL's Foresight Centre project lead Nicola Stacey whose email is: Nicola.Stacey@hsl.gsi.gov.uk or the EU-OSHA lead Emmanuelle Brun whose email is: brun@osha.europa.eu

What is your current job or position? If retired please state retired and give your job or position before retirement.

Which industrial sector(s) do you work in?

What is your Nationality?

What country do you work in? If you work across Europe or internationally please state Europe or International

How much expertise do you have in one or more of the following?

- Information Communication Technologies (ICT) or technologies enabled by ICT
- Likely future developments in ICT or technologies enabled by ICT
- How the workplace or workforce may change as a result of ICT

None Some A lot

How much expertise do you have in Occupational Health and Safety (OSH)?

None Some A lot

On the next pages are a list of Contextual Drivers of Change we have identified that could contribute to creating new and emerging risks associated with new information and communications technologies and work locations by 2025.

We would like you to consider the drivers grouped into the following STEEP categories:

- SOCIETAL
- TECHNICAL
- ECONOMIC
- ENVIRONMENTAL
- POLITICAL

On the next pages, please use the drop-down menus at the bottom of the page to select in EACH of the categories, which trends or drivers in order of importance you think could contribute to creating new and emerging risks associated with ICT developments and work locations by 2025. There is space for additional comments.

CATEGORY: SOCIETAL

We recommend printing this page before answering the questions on the next pages

You can do this using the print icon above the title or by right clicking and selecting print

Demographics and characteristics of the workforce

1. Population changes: While the global population is rising, the EU population is slightly falling where there is also a shortage of an active workforce.

2. Ageing workforce: Whilst the average age in the EU is increasing there are variations across the EU and, in general, lower average age in candidate countries.

3. Increasing migration into EU: Caused by large differences in standard of living between countries, refugees from conflict and facilitated by mobile devices providing ease of access to information about different countries and travel options.

4. Generational differences: Generational differences: Increasing length of working life means more generations in the workplace: From the “digital natives”; to those working for some time, coming close to retirement age or already retired, with very differing attitudes to hierarchical organisational structures, sharing information online and ease of using ICT at work.

5. More women in the workforce: Who tend to prefer and/or be more willing to have flexible working patterns.

6. Increasing number of workers with chronic and complex health problems: (including MSDs, cancers, mental health disorders, etc.) and the need for more inclusive and adapted workplaces, increasing incentives at policy levels and awareness-raising initiatives.

7. Increased inequality and polarisation: due to the benefits from technological innovation not being spread evenly across socio-economic groups with low paid unskilled workers at one end of the spectrum and a ‘digital elite’ at the other. This could be to such an extent that it causes social unrest and increased migration.

Employment Patterns

8. Flexible working patterns: Includes growth in demand (from organisations and/or individuals) for: flexible working hours; part-time (voluntary and in-voluntary); zero-hours’ contracts (or on-demand workers); shorter-term temporary contracts; self-employment; home working; mobile working.

9. Virtual workplaces: Working online anywhere and anytime such that location is irrelevant.

10. Crowd-working: Whereby an online platform is used to enable organisations or individuals to access an indefinite and unknown group of other organisations or individuals to solve specific problems or to provide specific services or products in exchange for payment.

11. Fluid co-working spaces: Shared physical work spaces where different individuals work who are generally not employed by the same organisation.

12. Changes to HR management: These range from surveillance and monitoring of workers location, activity and productivity by data profiling to flatter organisational structures where workers are supervised less, have more autonomy and are judged by innovation as well as output rather than just time spent at work.

13. Shift working: Since the global recession the number of people working regular night shifts has increased to more than 3 million (14.9% of men and 9.7% of women), with the possibility that this proportion will continue to rise.

Skills

14. Increases in basic ICT skills

15. Gaps in ICT skills: Due to growth in demand, the pace of change leading to skills becoming quickly outdated and declining numbers of people studying science, technology, engineering and/or mathematics.

16. Increasing need for advanced reasoning skills: Including, problem solving, judgement under uncertainty, creativity, interpersonal and emotional intelligence.

17. Life-long learning: Due to the high pace of change in the workplace and extended working lives, people are increasingly likely to need retraining several times during their careers.

18. Job mortgages: Due to changing working patterns workers are likely to have to take increasing responsibility for their own training. This may include workers borrowing money to cover the cost of training against their future potential earnings.

19. Quickening pace of knowledge transfer: Driven by instantaneous global communication and increasing networking.

20. Access to online education: Commercial, internal and massive open online courses (MOOCs).

21. De-skilling: For example due to increased use of automation.

Public Attitudes

22. Attitudes to and awareness of risk: Will affect the take up of new technology and working patterns.

23. Attitudes to online privacy: People may be concerned about privacy and security of data but they may still be willing to share data online because of the convenience it brings with it.

24. Public attitude to (acceptance of) ICT developments: Major new developments will be dependent on the acceptability of the technology to workers, which is dependent on whether it is seen as a threat to their preferred way of life / social model.

25. The future of collective action: There is diversity in union density across EU however the general trend is a fall in Trade Union membership. New online platforms for collectives may spring up to replace them.

26. Rise in workplace cyberbullying

27. Rise of the green lobby: May lead to more stringent control of carbon emissions and a change to workers' and organisations commuting preferences including a desire for more online working.

Urban Environment

28. Smart cities: Where ICT is used to manage a city's assets such as schools, hospitals, transport infrastructure, water, and energy supply such that they are integrated with community services.

29. Increasing Urbanisation: Individuals are increasingly moving to cities to work, this trend is set to continue over the next decade.

Are there any trends or drivers in the SOCIETAL category that you disagree with? If so please give the number and explain why.

Are there any trends or drivers that we have missed in the SOCIETAL category? If so please describe.

Please, using the drop-down menus decide in EACH of the categories, which THREE trends or drivers in order of importance you think could contribute to creating new and emerging risks associated with new and emerging ICT developments and work locations by 2025.

First Societal Trend or Driver

Please select one option.

Second Societal Trend or Driver

Please select one option.

Third Societal Trend or Driver

Please select one option.

Category: TECHNOLOGICAL

We recommend printing this page before answering the questions on the next pages

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Pace of change

30. Technological advances in ICT

31. Advances in computing power and speed

32. Technical challenges for ICT — such as limited electromagnetic spectrum, availability of energy, need for new types of transistor and battery charge-life may constrain continued developments and growth of use of ICT.

33. Need for new standards — to enable more and more different technological devices to 'talk' to each other. A lack of common standards may limit ICT advances.

34. Internet of things — potential for vast numbers of cheap sensors taking measurements opens up a wealth of possibilities for machine to machine (M2M) communication and pervasive sensors, especially when combined with Big Data analytics and machine learning.

35. Big data — is a combination of three trends: increasing rate of data generation; improving data storage; and advancing data analysis.

Autonomous Systems

36. Automation — any activity that is characterised by being repetitive, routine, structured and rules-based is likely to be automated over coming decades.

37. Robotics and collaborative robots — robots are becoming capable of carrying out ever more intricate tasks and of operating alongside people. They are also operating in an increasingly autonomous and self-learning way.

38. Bionics — robotic based technologies can be used to augment human activities and strength or overcome disabilities, for example through exoskeletons. Such devices are becoming increasingly available, cheap and capable.

39. Artificial intelligence (AI) — is typified by machines making rules based decisions autonomously from an operator and increasingly they are able to learn from experience.

40. Industry 4.0 — The 'Internet of Things' and machine to machine (M2M) communication is enabling an emerging trend of 'lights out' manufacturing (manufacturing without human involvement).

41. Additive manufacturing (also called rapid manufacturing or 3D printing) is an automated process that produces three-dimensional objects directly from digital models by the successive addition of materials.

42. Autonomous vehicles (AVs) are increasingly being used on private land and being tested on the public highway worldwide. Interim features, such as self-parking and collision avoidance assistance, are already being deployed.

43. Drones — their use for work purposes is expanding rapidly and this is expected to continue into the future.

Miniaturisation and Portability

44. Growth in mobile ICT devices as a result of increasing computing and battery life, coinciding with miniaturisation, faster and more widespread accessibility to WiFi, 5G and beyond.

45. Wearables — miniaturisation has happened to such an extent that devices, rather than being carried in bags or pockets, can increasingly be worn on the person or incorporated into clothing.

Advanced Human Machine Interfaces

46. Augmented reality (AR) — provides contextual visual information alongside real-world views.

47. Virtual reality (VR) — the use of computer technology to create a simulated, immersive 3D environment that can be interacted with. Most VR systems are head-mounted displays (HMD) but can be through a display screen.

48. Immersive communication — uses ICT technologies to create natural experiences and interactions with remote people and locations.

49. Interfacing via other human senses — such as via gesture-control, eye tracking technology, speech recognition and instantaneous translation are becoming increasingly capable and ubiquitous.

50. Direct brain to computer — non-invasive computer-to-brain interfaces including trying to produce perceptions through stimulating the brain are being researched and developed.

ICT services and infrastructure

51. Social media — is increasingly popular as a tool to enable individuals and businesses to communicate, network and collaborate across the world.

52. Cloud computing — allows workers across the world to work together by sharing data and information. By 2020, the amount of data going through the cloud globally is projected to be over double the amount in 2013.

53. Open intellectual property movement —concern has been expressed that unless Europe moves to an open data model, the digital economy is unlikely to progress.

54. Networking & inter-connectivity software-defined networking and Internet Protocol version 6 (IPv6) — advances in networking that will enable a far more secure, transparent, flexible, verifiable, and functional network.

55. 5G mobile technology — provides ultra-high broadband and full voice input capability with the potential to enable global instantaneous communication, with no time-lag.

56. Massive open online courses (MOOCs) — duplicate the best teachers, methods and course materials that are made openly available online to anyone and also apply analytics to better measure learner patterns.

57. Cybersecurity — attacks on companies' assets through their IT are becoming increasingly sophisticated and difficult to detect.

58. Advanced materials — a wide range of novel materials may improve the performance of many current ICT technologies and work environments.

Are there any TECHNOLOGICAL trends or drivers that you disagree with? If so please give the number and explain why.

Are there any TECHNOLOGICAL trends or drivers that we have missed? If so please describe.

Please, using the drop-down menus decide which THREE drivers in order of importance you think could contribute to creating new and emerging risks associated with new and emerging ICT developments and work locations by 2025.

First TECHNOLOGICAL Trend or Driver

Please select one option.

Second TECHNOLOGICAL Trend or Driver

Please select one option.

Third TECHNOLOGICAL Trend or Driver

Please select one option.

Category: ECONOMIC

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Globalisation

59. Rising globalisation — has shown fairly steady growth from 1980 and expectations are that it will continue apace.

60. Offshoring — is currently used by the majority of large companies for manufacturing. Whilst there is uncertainty about whether this will continue to rise there is expected to be a rise in the offshoring of knowledge based work facilitated by the digital economy and crowd-working.

61. Reshoring — There is some evidence that ICT advances such as 3D printing and automation, along with concerns about quality and rising costs are beginning to create a trend towards companies moving their manufacturing closer to home.

62. Increasingly well-educated Asian workforce — it is projected that by 2030 India and China will provide at least 60% of workers in science, technology, engineering and mathematics.

Macro-economic environment

63. BRIC countries — The BRIC countries (Brazil, Russia, India and China) are the fastest growing and largest emerging markets.

64. EU growth since financial crash of 2008 — assumptions of steady growth across Europe have been challenged and public debt limits are putting constraints on investment.

65. The economic value of data — in order to create a data-enabled economy there is a need for data to be valued economically and included on balance sheets. Data sets could be traded through a regulated framework.

66. Insurance — if perfect data becomes available there is the possibility that low-risk businesses may no longer feel it necessary to purchase insurance.

Changing industry structure

67. Micro and small and medium-sized enterprises — globally, there is an ongoing rise in the number of Micro as well as Small and medium-sized enterprises (SMEs).

68. Effect of ICT on other sectors — advances in ICT will continue to have an impact on the amount and types of jobs accessible and the skills needed in different sectors.

69. Alternative distribution chains — increasing sales direct to consumers, between peers and consumer to consumer.

70. Rise of the entrepreneur — digital technologies help the entrepreneur of the future as they allow low start-up cost and fast scale-up.

71. Increase in e-commerce — driven by the increasing pervasiveness of mobile internet devices and has resulted in an ongoing decline in retail jobs, but increases in logistics jobs.

72. Increasing knowledge economy — is an ongoing trend towards trading in knowledge and information rather than physical artefacts.

73. Rise in the service sector — an ongoing increase is being experienced in Europe.

74. Sub-contracting — the growth of the self-employed and increased globalisation tends to drive a growth in sub-contracting.

New business models

75. Sharing economy — the sharing rather than owning of assets such as cars appears to appeal to the 'millennial' generation, so can be expected to grow further and may extend more into sharing of work equipment along the lines of a modern equivalent of agricultural co-operatives.

76. Peer-to-peer finance as well as crowd-sourced funding are becoming a more prevalent source of funding for innovators to get their inventions to market.

77. Servitisation — where the service provider owns the product that provides a service rather than the consumer of the service.

Are there any ECONOMIC trends or drivers that you disagree with? If so please give the number and explain why.

Are there any ECONOMIC trends or drivers that we have missed? If so please describe.

Please, using the drop-down menus decide which THREE drivers in order of importance you think could contribute to creating new and emerging risks associated with new and emerging ICT developments and work locations by 2025.

First ECONOMIC Trend or Driver

Please select one option.

Second ECONOMIC Trend or Driver

Please select one option.

«Please select»

Third ECONOMIC Trend or Driver

Please select one option.

«Please select»

Category: ENVIRONMENTAL

We recommend printing this page before answering the questions on the next pages

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78. Climate change — analysis suggests that global warming will be more substantial (at 2.7°C) and occur sooner (by 2036) than previously predicted.

79. Energy — ICT currently uses a significant amount of the world's electricity, generating approximately 2% of global carbon dioxide emissions. ICT development may be effected by energy shortages that could occur if innovations in energy generation are not sufficient.

80. Limited supply of rare earth metals — rare earth metals are essential in many ICT-based technologies. There are increasingly fewer levels worldwide and China, as a producer has restricted exports.

81. Circular economy — waste ICT equipment could become increasingly seen as a valuable commodity as a raw material for new ICT equipment.

82. Disease — after 70 years of successful use, the effectiveness of antibiotics is lessening as more microbes are evolving to become resistant. In a more connected world and also because of climate change, the risk of pandemics and diseases arriving in Europe from other parts of the world becomes higher.

Are there any ENVIRONMENTAL trends or drivers that you disagree with? If so please give the number and explain why.

Are there any ENVIRONMENTAL trends or drivers that we have missed? If so please describe.

Please, using the drop-down menus decide which SINGLE driver you think could contribute to creating new and emerging risks associated with new and emerging ICT developments and work locations by 2025.

ENVIRONMENTAL Trend or Driver

Please select one option.

Category: POLITICAL

We recommend printing this page before answering the questions on the next pages

You can do this using the print icon above the title or by right clicking and selecting print

Political Agenda

83. The European digital single market — is one of the European Commission's ten priorities. A digital single market in Europe could create hundreds of thousands of jobs and bring 415 Billion Euros to the EU economy each year.

84. e-Government — the prevalence of e-Government across the EU varies substantially, but is increasing everywhere.

85. Security and privacy — two sides of the same coin, as governments believe they need to monitor internet communications more thoroughly to prevent terrorism, the public begins to become more concerned about its privacy.

86. Investment in education and employment initiatives — It will be increasingly difficult for Governments to find funds for education and employment initiatives due to competing demands for expenditure.

87. Control of migration — the recent surge in migration from the Middle East and Africa has led to major re-thinking of immigration policies across Europe.

88. Regulation of new working patterns — many of the new working patterns are not well served by existing regulations.

89. Governance of the internet — as internet use has increased there has been a corresponding rise in its regulation.

Instability

90. Terrorism and war — terrorist attacks in European capitals cause a reduction in travel and a concern about living/working in large cities. Generally these effects wear off after a while, but if attacks were to increase in frequency and severity then there could be a noticeable effect on patterns of behaviour.

91. Increasing geopolitical volatility

92. Blurring of borders — increased globalisation, the rise of digital work platforms and an increasingly networked world means that borders may become blurred or even cease to exist.

Are there any POLITICAL trends or drivers that you disagree with? If so please give the number and explain why.

Are there any POLITICAL trends or drivers that we have missed? If so please describe.

Please, using the drop-down menus decide which TWO drivers you think could contribute to creating new and emerging risks associated with new and emerging ICT developments and work locations by 2025.

First POLITICAL Trend or Driver

Please select one option.

Second POLITICAL Trend or Driver

Please select one option.

If you could spend some time with someone who knew the future, a clairvoyant or oracle if such existed, what would you want to know? i.e. what are the critical issues?

Do you have any final comments?

Thank You for completing this survey

If you are willing to participate in subsequent stages of this research please provide your name and email below.

If you provide these details here your answers remain anonymous and we will send you a link to the project report when it is available.

Appendix E: First web survey ranking of trends and drivers

The following figures show the ranking of the trends and drivers (identified during Task 1) as a result of the choices respondents made when asked which trends and drivers they thought were the most important under each STEEP category. The colours indicate how many were first, second and/or third choices, where relevant.

Figure E1: Ranking of societal trends/drivers as a result of web survey respondents' choices (*n* = 66)

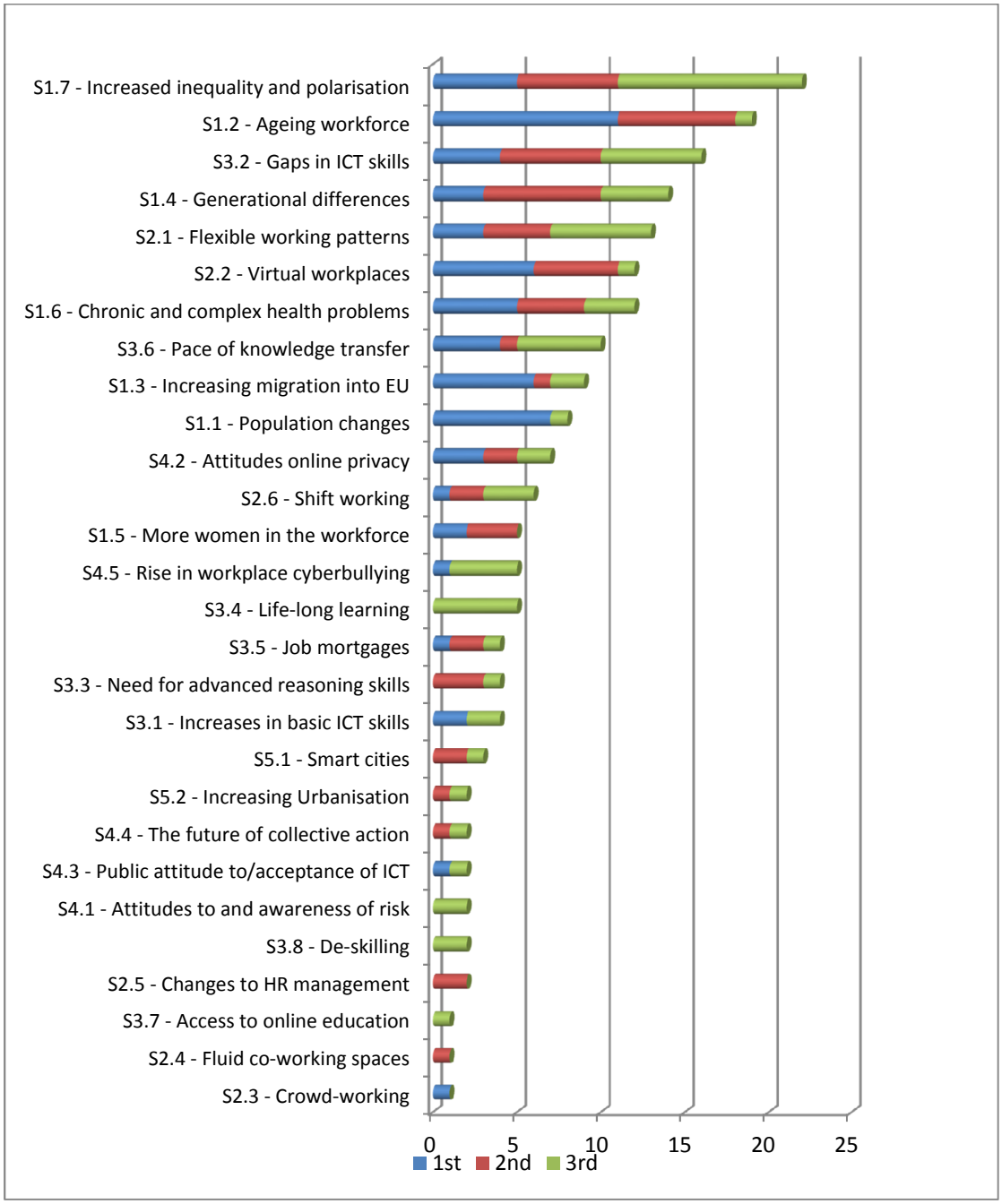


Figure E2: Ranking of technological trends/drivers as a result of web survey respondents' choices (*n* = 58)

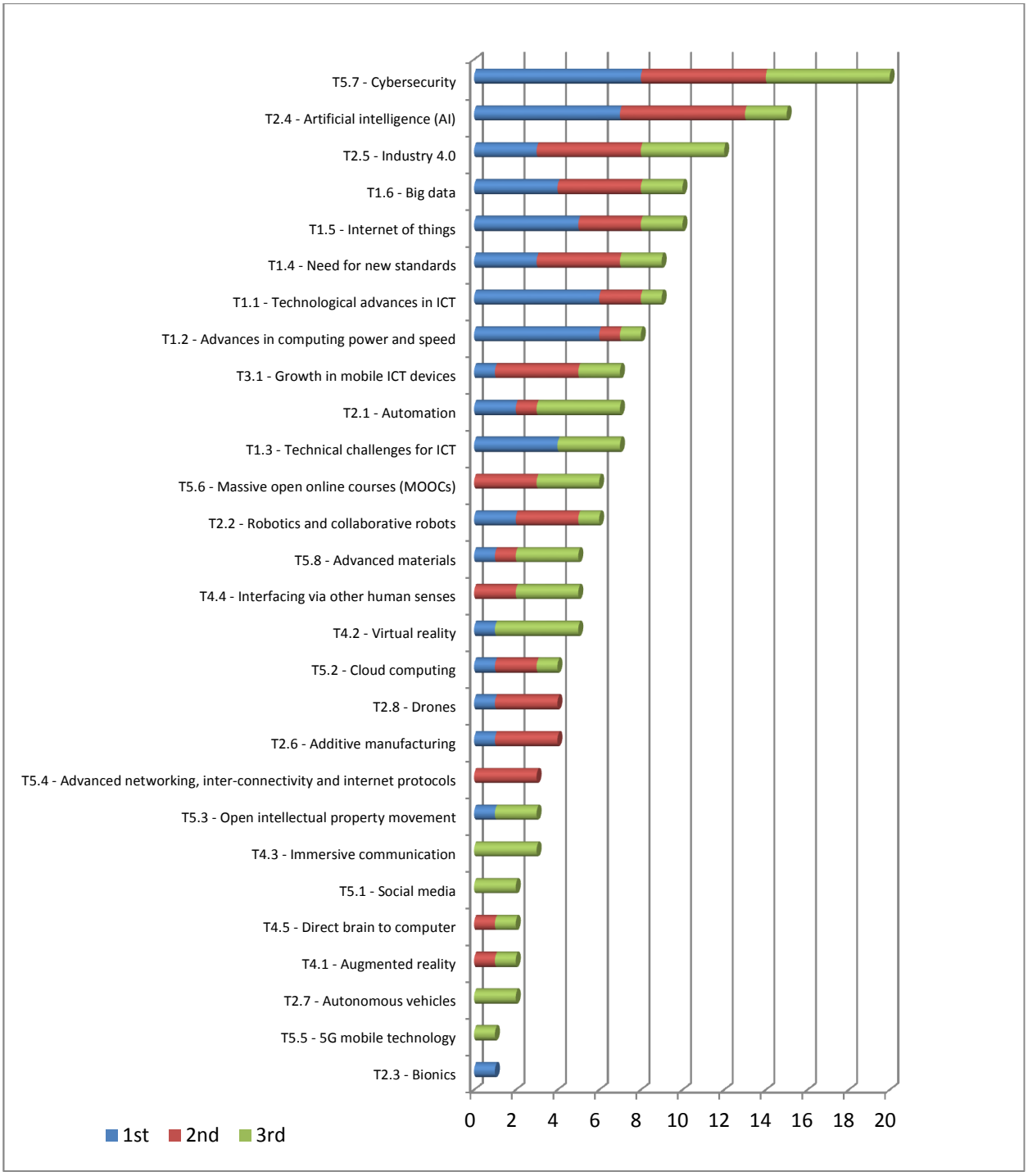


Figure E3: Ranking of economic trends/drivers as a result of web survey respondents' choices (*n* = 57)

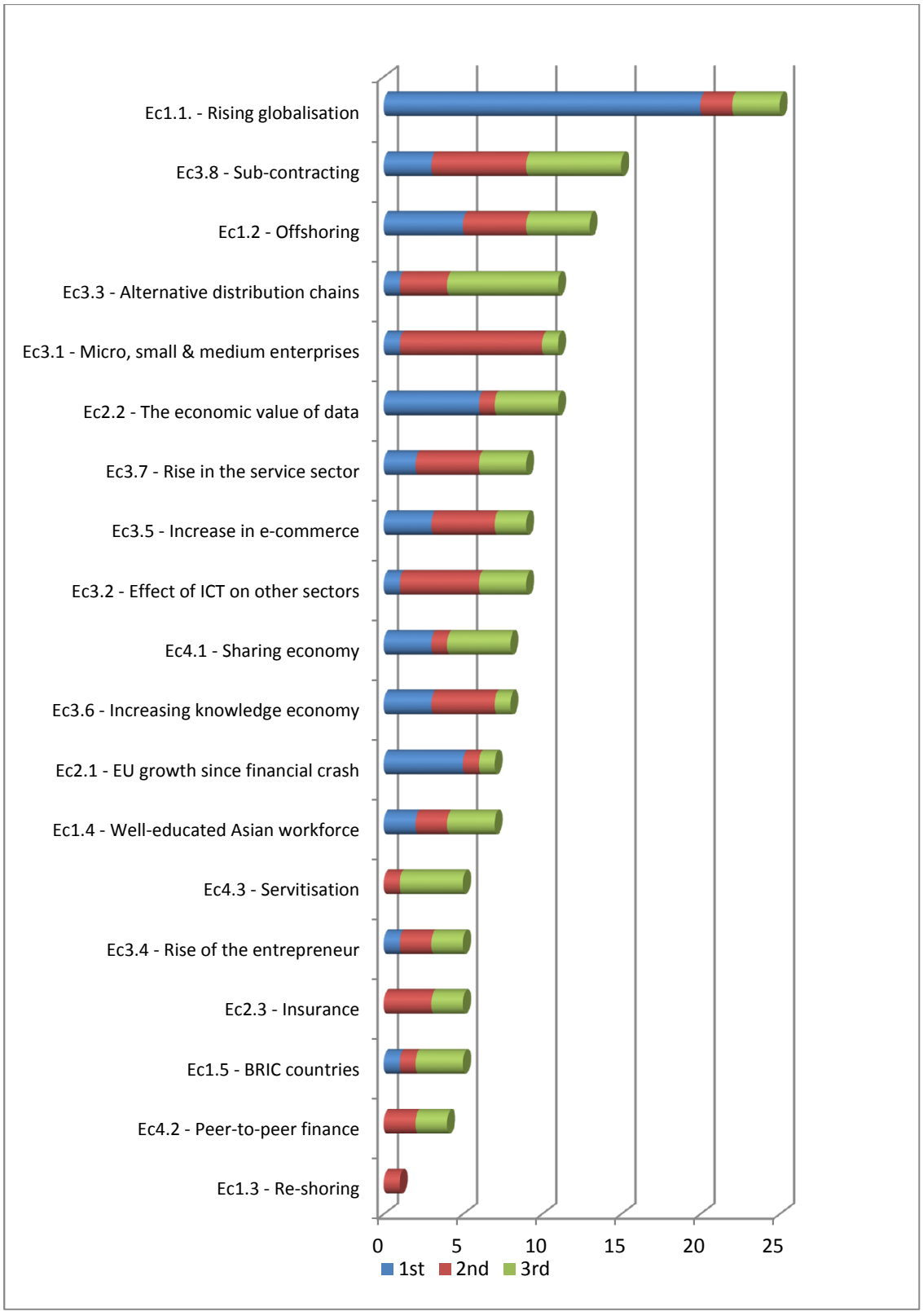


Figure E4: Ranking of environmental trends/drivers as a result of web survey respondents' choices

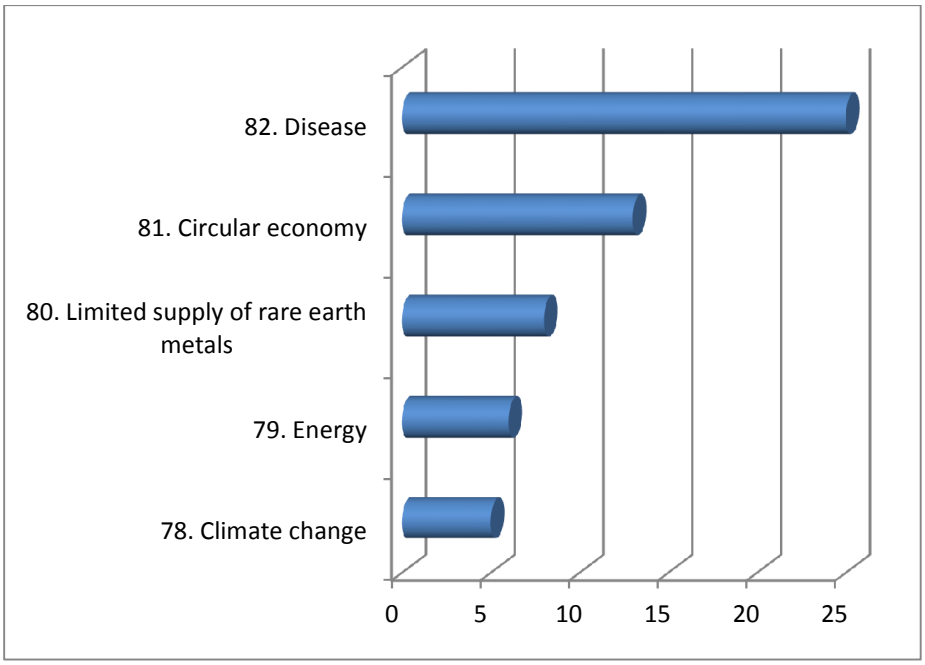
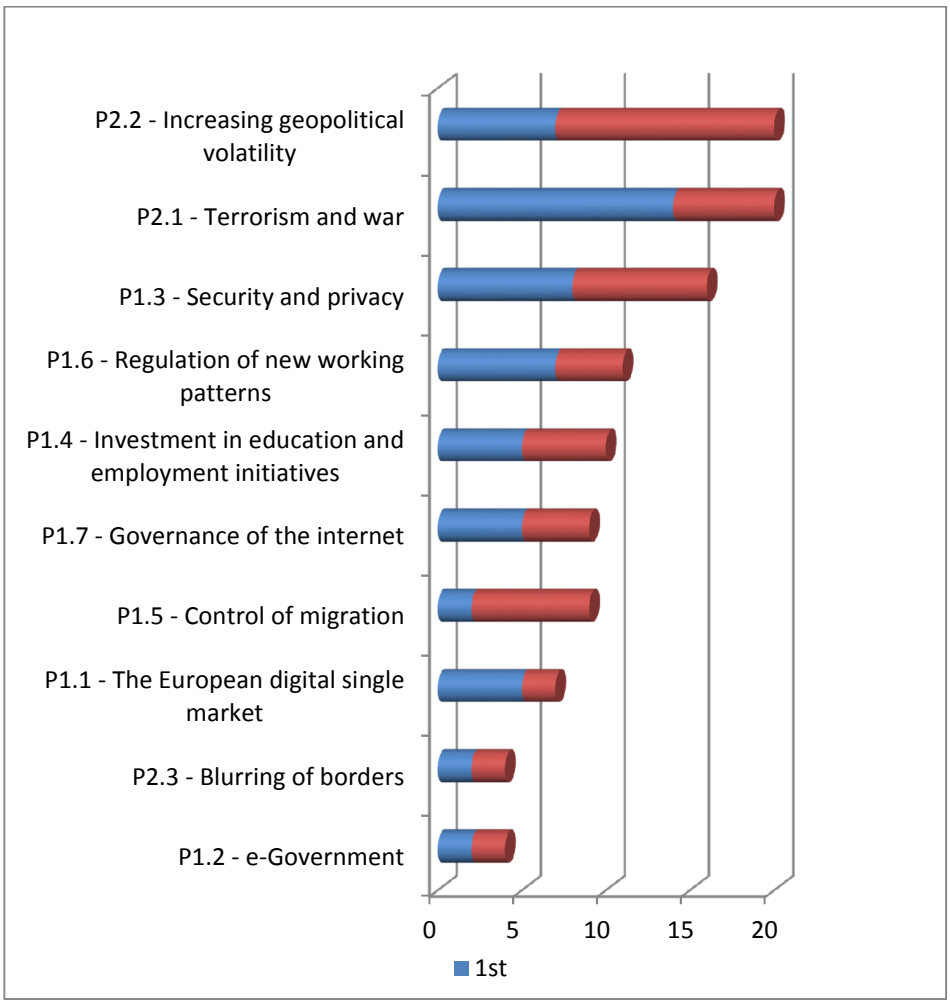


Figure E5: Ranking of political trends/drivers as a result of web survey respondents' choices (*n* = 57)



Appendix F: Extent of agreement in follow-up survey with rankings from first web survey.

The responses given to each of the questions in the follow-up web survey are given in the tables below, one for each STEEP category, with each row containing comments made by the same respondent.

Table F1: Comments on the ranking of societal trends and drivers

Extent of agreement with those trends and drivers scored as MOST important	Extent of agreement with those trends and drivers scored as LEAST important	Further comments
Agree but miss social risk — loneliness.	Yes agree.	Agree.
I quite agree with the first six ones, nevertheless aspects such as life-long learning, more women in the workforce will have a great impact in a short future.	Future of collective action is still a 'grey area' in legislation and labour law, reason why the lack of awareness may explain the position on the list. Public perception/attitude seems a relevant area for OSH to have some influence in terms of educating policymakers as well as general public, workers, etc.	Crowd-working have been tackled for the last years in terms of several research and analysis.
I think that generational differences are more important than gaps in ICT skills.	I completely agree.	No.
I agree with them.		
I agree with the trends identified as more important. Nevertheless there are some items that it should be in the first place of the ranking, as shift working or the life-long learning. I consider that those trends are more related with OSH and by that could contribute to a better workplace with less workplace failures and accidents.	I cannot be in accord with some trends considered as less important as for instance the changes to HR management. In my opinion any changes in the organization affects workers in a very important measure. People are one of the most important things in organizations. We can have very important results by promoting a good and safer environment to people. So the human resource management (HRM) should be in the top of the ranking and not in the end.	No.
I agree with these trends. I think that the gaps in ICT skills and the ageing workforce are correlated. The gap between a young worker and a senior worker in ICT could be quite big. Therefore a senior worker could feel inadequate and this 'feeling' can make the difference in the relationship with the other colleagues.	I agree, I don't think that those trends are so relevant.	No.

Extent of agreement with those trends and drivers scored as MOST important	Extent of agreement with those trends and drivers scored as LEAST important	Further comments
Fully.	I believe de-skilling and crowd working will be more important in the future, much more.	None.
I agree that the ageing workforce is important and I note that this received most first choices.	I suspect crowd workforce came last because no one knows what it is.	No.
I agree the top 10 are the most important. I'm surprised 'De-skilling' is so low — AI will certainly lead to that. I do think the rise of the green lobby could be important too.	De-skilling should be higher. The others are still important even if ranked lowest.	No.
I agree with the first two, but not with the third. There will be so many incentives for people to maintain and improve their ICT skills — not least competition for jobs — that I feel confident that it will happen naturally.	The bottom nine — in terms of scoring — are pretty much equal last. I would pick out one: The Future of Collective Action. I think we may see much more than we think — in the form of blockchain, communities of interest etc. leading to local financial systems (Bitcoin or the Bristol Pound); local networks for small enterprises and for local 'grids' based in renewable energy generation and storage.	I see the possibility (under some scenarios) of serious societal rifts as economic (e.g. inequality and insecurity), demographic (the cost of the ageing population) and other pressures (e.g. large-scale and uncontrollable migration) intensify.
Think generational differences are going to be more important — may also show up as ageing workforce and inequality.	Access to online education is really important if it includes learning to read by experimenting with PCs (experiments in Africa).	Green lobby — now taken into government policy but having mega-effect.

Table F2: Comments on the ranking of technological trends and drivers

Extent of agreement with those trends and drivers scored as MOST important	Extent of agreement with those trends and drivers scored as LEAST important	Further comments
Agree but surprised by lack of wearables.	Surprised think it has been skewed by current events — be interested to see responses if those top 2 were removed.	
I quite agree with the results. It's interesting to see need for new standards associated to ICT development as one of the main complaints to policy is the lack of adaptation to todays or future conditions.	Wearables and augmented reality. I still think there's much potential for these areas to have a better link with OSH.	
I think need for new standards will be very important.	Autonomous vehicles, it's a real trend and should be in an upper position.	No.

Extent of agreement with those trends and drivers scored as MOST important	Extent of agreement with those trends and drivers scored as LEAST important	Further comments
I agree with the first trends, because I think that they are the most aspects promoting the existence of higher risk.	I also agree with the classification of the least important. Some trends in the middle make me have some doubts as for instance the additive manufacturing, because I cannot consider that trend as less important as for instance virtual reality.	No.
I mostly agree but I think that the Technological Advances ICT is one of the most important trends.	I agree with them.	No.
I would rate 'Bionics' higher up.		Robots will become much more important in the future.
I don't know what Industry 4 means. I'm very surprised that social media isn't higher.	Autonomous vehicles are surely very risky. Why are they ranked so low?	No.
I don't think cyber security should be top — it is a challenge, but not as pervasive as AI, IoT, big data. I do think wearables will be important in health and environmental exposure monitoring.	I'd put AVs higher up. Bionics could be important but probably longer timescale. I'd certainly include wearables.	No.
Networks — whether 5G or something else — to allow the transmission of vast quantities of data, are a necessity, as well as computing power and speed. Also, Social media/Blockchain/communities of interest will increase in importance in response to the increasing power of global corporations and loss of faith in Governments.	5G mobile technology (or whatever follows it) is far too low in the list. It's critical to the development of this new world. I think the same is true of social media (including blockchains), although that is not as fundamental a requirement. Augmented reality is scored low, I suspect, because we don't really understand it yet.	3D printing is not a new technology, but I understand that many patents are coming up to expiry: so we may see a giant step forward in access to 3D printing as the technology becomes more accessible to more manufacturers.
The factors are interlinked but the top 5 are an important cluster.	Wearables is one way in which consumers use ICT — the next wave will be dominated by individuals making decisions based on their assumptions of and use of ICT, moving much faster than organisations.	

Table F3: Comments on the ranking of economic trends and drivers

Extent of agreement with those trends and drivers scored as MOST important	Extent of agreement with those trends and drivers scored as LEAST important	Further comments
The trends first identified are representative of the vision of OSH more aligned to Social, Environmental, Economic Sustainability.		How the concept of traditional supply chain will evolve?
I agree, especially with the importance given to micro and small and medium-sized enterprises. The lack of economic power of micro and SME can contribute in large amount to OSH risks, and in many EU countries is a very important issue.	I agree with the trends classified as the least important in all extent.	No.
I agree with these trends especially with the Rising Globalisation and the Sub Contracting.	I agree.	No.
Basically agree, however, I believe 'debt' will be an increasing problem in the Western World. But not only there ...	BRIC countries should be ranked further up.	Technology will make reshoring economically and technologically much more likely in the future.
I broadly agree.	I broadly agree.	No.
I'd put 'increasing knowledge economy' higher — it's a very strong trend.	I think they are probably the right ones.	The economic impact of Brexit ought to be in here somewhere.
Offshoring may become LESS important, as AI and robotics undermine the current pull factor of cheap labour. There is some evidence of 'reshoring' of work from Asia to the West.	I think reshoring may very well become more of a factor — although it won't be a job creator. Cheap labour jobs will be lost, and work will be re-shored to automatic/robotised plants.	On a semantic point, I don't think BRIC is a useful term. While there is a certain logic to yoking India and China together as emergent powerhouses (and both of which dominated the global economy before the West had its industrial revolution), Russia and Brazil are both — in their different ways — not comparable. Russia is essentially dependent on oil and gas (both of which seem to be heading into a long-term decline; and Brazil is a rich source of materials, but not yet at first base in terms of developing its own autonomous economy.

Extent of agreement with those trends and drivers scored as MOST important	Extent of agreement with those trends and drivers scored as LEAST important	Further comments
They all take a corporate focus. Most economists now recognise that individuals making decisions is the most important factor in the economy.	Agree that BRIC is no longer the issue: India is progressing slowly but surely and will compete with western economies on a wide front, China has benefited from urbanisation and adding people to the formal economy but this is now of diminishing returns, Brazil's path away from dependence on commodities is fraught, Russia has a declining population and a decreasing revenue from commodities with little possibility of reversing these trends — however militarily, Russia is looking to recompense for these.	

Table F4: Comments on the ranking of environmental trends and drivers

Extent of agreement with those trends and drivers scored as MOST important	Extent of agreement with those trends and drivers scored as LEAST important	Further comments
I would indicate as more important after disease and circular economy the energy and climate change, because I think that both can affect more OSH.	For me the limited supply of rare earth metals should be the least important trend.	No.
I agree.	I agree.	No.
Changes in the energy sector will be much more important in the future.	As mentioned, I think changes in the energy sector will result in a higher ranking of it.	
How can climate change not be top? Why is disease thought important to ICT in 2025? Crazy.	As above.	No.
Fundamentally disagree. Climate change tops everything, with energy second.	As per previous answer — I think the order should be totally reversed.	Air pollution should be in there — an increasingly important issue.
I'm sceptical about the importance attached to disease. Advances in genetech and biotech make me optimistic about our ability to continue to keep one step ahead of diseases. Energy is critical. I infer from the low ranking given to it that people think that the problems of energy security will be solved. I probably agree!	Energy is critical, but I agree with the low ranking on the assumption that problems of energy security will be solved.	Not sure whether food production and access to water belong here. Maybe they should have been included.

Extent of agreement with those trends and drivers scored as MOST important	Extent of agreement with those trends and drivers scored as LEAST important	Further comments
Yes, disease is a growing threat as more people travel and as more diseases are resistant to treatment.	Energy is a major driver. The change from centrally driven energy provision to consumer driven energy provision (e.g. solar panels) will be not be smooth.	

Table F5: Comments on the ranking of political trends and drivers

Extent of agreement with those trends and drivers scored as MOST important	Extent of agreement with those trends and drivers scored as LEAST important	Further comments
I truly believe that future changes on the Digital agenda, regulation of new working patterns and governance of the internet should be in higher positions.		
I completely agree.	I think all are very correlated.	No.
In our days I have to agree with the trends considered as more important.	I agree with the trends considered least important.	No.
Terrorism is a serious threat, so I agree with the position it has.	I agree.	No.
Fully agree, although e-Government should rank higher.		
I broadly agree.	I broadly agree.	ICT and work location seem quite separate issues. I don't think it likely that respondents understood the concepts underlying this questionnaire.
Top 3 are right.	e-Gov could be important for OSH if it is successful.	May be seeing the end of neo-liberal political theory and an acceptance of the need for more intervention — which would help OSH.
It's interesting that geopolitical volatility and terrorism/war occupy the top two places. Most studies show that the world has never been more peaceful. Of course it's risky to extrapolate forward from present trends (which is why economic and other models are often so wayward) but I think both of these show people are subject to cognitive bias. We read more about war and terror in the media, so we think there is more of it about, when the reverse is true.	Blurring of borders and migration are going to be major political issues. The population of Africa is set to increase by 50% by 2050 and to go on to double by the end of the century. The pressure of people seeking a better life beyond their home countries will increase, and create massive business opportunities for people smugglers.	There is an uncertain future for national governments — with the rise of transnational blocs on the one hand (EU, NAFTA, ASEAN) and the growth of localism and regionalism on the other (Scotland, Catalonia etc). That should feature somewhere.

Extent of agreement with those trends and drivers scored as MOST important	Extent of agreement with those trends and drivers scored as LEAST important	Further comments
Top three highlight volatility and insecurity — think the stats show these reducing globally.	e-government is massive: people's views change much faster than organisations can respond.	

Appendix G: Modification to trends and drivers

The following comments from interviewees provided useful additional detail:

- 'Apps are a better way of giving people OSH information than manuals', which has been added as an opportunity resulting from S3.1, 'Increase in basic ICT skills', and T5.1, 'Growth in mobile ICT devices'.
- 'Now tend to have to provide your own equipment — BYOD [Bring Your Own Device] issues of security and consistency', which has been added as an implication of S2.1, 'Flexible working patterns', and as an important factor in T5.7, 'Cyber-security'. It was already mentioned in S2.2, 'Virtual workplaces'.
- 'There is increasing huge complexity in modern computer systems', which has been added as an implication of T1.1, 'Technological advances in ICT'.
- 'Stability of legacy computer systems for infrastructure', which has been added as a new example for T1.3, 'Technical challenges in ICT'.

These have been incorporated into the detailed descriptions of the consolidated trends and drivers in Appendix J.

Various comments indicated that some of the trends and drivers needed to be modified. The changes made, along with the comments that led to the changes, are shown in Table G.1. Other comments led to the identification of two additional trends and drivers. The new trends and drivers and the comments that led to them are shown in Table G2.

There were several general comments about the large number of trends and drivers and the need to consolidate them. After consideration by the project team, the following trends and drivers have been combined as described below:

- 'Access to online education, e.g. massive open online courses (MOOCs)' was listed under the societal 'Skills' sub-category and MOOCs were included in the technological sub-category 'ICT services and infrastructure'. After consideration, the project team felt that this was unnecessary, that MOOCs should only come under S3.7, 'Access to online education', and that T7.6, 'MOOCs', should be removed from the list.
- 'Shift working' (S2.6) is a type of flexible working pattern and has, therefore, been incorporated in S2.1, 'Flexible working patterns'.
- 'Networking and interconnectivity — software-defined networking and IPv6' (T5.4) and '5G mobile technology' (T5.5) have very similar impacts and have, therefore, been merged to form a modified driver, T7.4, 'Advanced networking, internet and WiFi protocols'.

The project team also took the opportunity to revise the name of the driver S4.6, 'Rise of the green lobby' to 'Decarbonisation, green targets and sustainability', as it was felt that this better described the driver.

Table G1: Trends and drivers modified as a result of interview comments

Ref.	Original trend/driver	Modified trend/driver	Interview comments
S4.1	Attitudes to and awareness of risk (employees)	Attitudes to and awareness of risk (all relevant stakeholders)	Technology is changing fast, so employers/managers need to be able to set the lead in managing their people to use new technology safely. People need to understand the technology well enough to appreciate the risks it poses. There is a danger of viewing it as a black box

			and then not really seeing the risks or knowing how to deal with the outputs.
S4.3	Public attitude to (acceptance of) ICT developments	Public attitude to (acceptance of and demand for) ICT developments and ethics	Need to put social scientists and designers on every technology team, to think about the impact on people, to think about the ethics. It's not about the technology, but the people. We need to be raising awareness; it's about ethics. We are increasingly dependent on ICT and information technology. Increased [traffic] congestion makes teleworking more appealing. We are so reliant on smartphones and tablets, has it become a part of people? It is changing our personalities, are we developing into different human beings?
T4.5	Direct (non-invasive) computer-to-brain interfaces	Direct computer-to-brain interfaces (invasive and non-invasive)	Will we have brain implants?
P1.7	Governance of the internet	Governance of ICT-ETs	How will we govern ICT? It is vital that OSH regulators stay at the forefront of these computer system technologies. Current regulation is cumbersome and based on very complicated policy. Too many strong regulations hold ICT innovations back.

Table G2: Trends and drivers added as a result of interview comments

Ref.	Additional trend/driver	Interview comments
T1.7	User-centred design — if technology is designed with the end-user's needs and OSH in mind, then it is more likely to be widely and successfully adopted.	Paying attention to the user experience during system or product design. New technology is implicitly built on the cultural norms of the designers, rather than the users. Most companies develop technology without thinking about by whom or how the technology will be used. Need a more human-centric approach; involve end-users in systems design from the beginning, rather than expecting them to adapt to it. IT systems not really being adapted to the workplace, not adapted to the end user.

Ec2.4	Availability of investment funding — availability or lack of public or private investment will affect the pace of change.	Availability of private investment for ICT in general. Put together a structured European industry oriented program of work to roadmap how industry can benefit and address roadblocks and evolve over time. Bring all technologies and large and small industries together. This will need funding and political will.

The following comments from interviewees provided useful additional detail:

- 'Poor offline ability (e.g. rural, mining)', which has been added as another example for T1.3, Technological challenges for ICT.
- 'More sophisticated search facilities', which has been added as an opportunity resulting from T2.4, 'Artificial intelligence'.
- 'More use of renewables and clean energy will surely be a trend', 'Increased use of renewables and clean energy will have an economic effect' and 'More direct energy generation for devices e.g. solar', which have been added as possibly mitigating the issues raised under Ev2, 'Energy'.
- 'Will future employment be able to provide most workers/employees with sustainable incomes, i.e. can you make a living and generate savings with a 40 hours/week job?', which has been added as an implication of S2.1, 'Flexible working patterns'.

These have been incorporated into the detailed descriptions of the consolidated trends and drivers in Appendix J.

Various comments indicated that some of the trends and drivers needed to be modified. The changes made, along with the comments that led to the changes, are shown in Table G.3.

Table G3: trends and drivers modified as a result of responses to open questions in the web survey

Ref.	Original trend / driver	Modified trend / driver	Web survey responses
S4.3	Public attitude to (acceptance of) ICT developments	Public attitude to (acceptance of and demand for) ICT developments	The problem of the 'continuum' of technology development and the 'continuum' of obsolescence of the worker. Every five years there is a relevant innovation in the technology. As you can see in the development of the cellphone then smartphone then watch phone and so on. Or if you want refer to 'software side' there is a generation Facebook then a generation WhatsApp then a generation 'Snapchat'. Every five years we must change the way we use the technology so the generation 'smartphone' or 'Facebook in a watchphone' or "Snapchat" environment is obsolete. The obsolescence is not technical but is in the 'mental way' (how and when using the technology) This is interesting in that it is very much driven by fashion hence being put under SOCIETAL rather than TECNOLOGICAL. Fashion and the power of marketing. e.g. iPhones / apple device don't really have a

			USP but they are hugely more expensive and popular due primarily to their marketing based on fashion.
S4.5	Rise in workplace cyberbullying	Discrimination, violence and bullying	The evolving nature of new forms of violence and its collaterals with dignity, discrimination, defamation, privacy invasion, particularly prevalent in education, media and healthcare sectors. The emerging of digital discrimination as a form of work related violence and the specific impact on vulnerable groups and technology related sectors. Sexual discrimination in cyberspace (sex discriminatory cyber harassment).
Ec1.1	Rising globalisation	Changes in levels of globalisation	Reactions against globalisation leading to protectionism. Tariffs etc. Will nationalism impede the growth of globalisation?
Ec1.5	BRIC countries	Emerging economies	Rise of MINT countries. Increasing prosperity in Eastern Europe. Will the EU in 30 years still [be] one of the major players in the world, or will Asia have taken over?
Ev3	Limited supply of rare earth metals	Limited availability of natural resources	Access to food and water. Water shortages limiting ICT use.
Ev4	Circular economy	Green economy [to include sustainability and recycling]	Re-cycling and re usage. In all areas — clothes, furniture, source code, phones and hardware. Sustainability and its link with OSH. Issues around pollutant waste.
P1.7	Governance of the internet	Governance of ICT-ETs	Labour protection in the digital economy. Occupational Safety and Health should recover its importance as a social right. Policy to gather accurate information about the scale of the activity, the legal and contractual conditions under which they are carried out, their working conditions, the environments in which they work and the associated risks for workers, clients and the general public.

			Where are the boundaries to what is possible with ICT? If there are no boundaries, then how do we regulate and control the use of ICT? Suitable OSH legal systems that can guarantee protection to workers on the same basis as in the 20th century with other traditional risks. We are at a time of critical change in history, and we aren't aware of the impact on future generations. It's time to act and change people's lives, politicians have to agree on the vision in the medium and long term and already apply laws to correct what we are doing wrong.

Appendix H: Trends and drivers respondents disagreed with

Table H1: Trends and drivers with which respondents disagreed, with reasons where given

SOCIETAL			
Demographics and Characteristics of the Workforce		**Responses**	**Tot.**
S1.1	Population changes	There is long-term youth unemployment in much of the EU keen to be part of an active workforce. Net migration means the local population is increasing.	3
S1.2	Ageing workforce	Migrants are predominantly younger.	1
S1.3	Increasing migration into the EU	[No reason given.]	1
S1.4	Generational differences	Those working for some time will adapt. Different generations have different opinions relating to work/life balance and in the future the 'traditional' view of women working less/needing more flexibility will probably change in line with different values. Fathers can and will need flexible working too, especially as more working parents share child care responsibilities. Millennials are not a homogenous group. It could be hazardous to generalize generational behaviours.	3
S1.5	More women in the workforce	Not so big influence. It would be appropriate to consider whether the fact that they are women who opt for more flexible working patterns is due to one reason or preferably a subject of social prejudice. Proof of this is the fact that men who have the same working conditions — and in some cases they have requested — are discouraged and feel that are judged by their bosses and their careers not they will prosper. I agree that this a likely trend, but I think it's an oversimplification to think that just 'mothers' will want to work flexibly. Women on ICT labour market are dramatically less employed.	4
S1.6	Increasing number of workers with chronic and complex health problems	Really? Does the data show increase in prevalence of long-term disorders?	3

		People are healthier and living longer than ever. Better health treatments.	
S1.7	Increased inequality and polarisation	I can't see the underclass being digitally excluded — they will have smartphones. If you take the mobile phone as an example, my experience shows there is very little difference in the ability to use this type of technology between low paid unskilled workers and highly paid professionals. ICT is cheaper every day. Most advances are free. I don't fully disagree but still I have some doubts. How this is presented and especially the social unrest and increased migration part sounds too strong for me. I don't think the two ends will be digital elite and unskilled. If digitally unskilled they can work in production, storage, utilities, maintenance. On other side the digital group is already too polarized and in ICT there is a wide gap in wages, but this to my opinion is driven by the wide gap in responsibilities and stress that comes with the type of ICT job you are working/willing to work in. If unskilled generally, this is a problem all over the world and inequality sure comes with it ... ON THE CONTRARY ICT could be a major driver for change in inequality — with all the free online courses, open sources of universities all over the world, the large number of educational materials, to do videos and practice lessons and so on ... I do not think exist a ‘digital elite’ or there will be a separation between unskilled workers and a ‘digital elite’. I think that in the future the ‘elite worker’ will be ‘unconnected’ with the ICT and will use the ICT only to verify the work of the other worker that much will use the ICT. In other words I think that in the future will be a ‘apex elite’ that will use only the ICT to share own ideas or project and to review report or the ‘abstract’ of the work of other people that will be totally involved with ICT.	6

Employment Patterns			
S2.2	Virtual workplaces	Will virtual working places reduce the need for office space? There are clear links to solo working and virtual spaces with loneliness, so the role for some kind of balance between working in an office for some time and working independently could be significant in the future.	1
S2.4	Fluid co-working spaces	[No reason given.]	1
6	Shift working	Less workforce in industry.	1
Skills			
S3.1	Increases in basic ICT skills	Attended by schools, university ... I think the trends come from an informed middle class western perspective which assumes continuing economic growth. I fear that a counter trend will be for more low pay jobs which cannot easily be done by robot combined with economic stagnation. That will not require the skills implied.	2
S3.2	Gaps in ICT skills	I think the trends come from an informed middle class western perspective which assumes continuing economic growth. I fear that a counter trend will be for more low pay jobs which cannot easily be done by robot combined with economic stagnation. That will not require the skills implied.	1
S3.3	Increasing need for advanced reasoning skills	I think the trends assumes continuing economic growth. I fear that a counter trend will be for more low pay jobs which cannot easily be done by robot combined with economic stagnation. That will not require the skills implied.	1
S3.4	Lifelong learning	I think the trends come from an informed middle class western perspective which assumes continuing economic growth. I fear that a counter trend will be for more low pay jobs which cannot easily be done by robot combined with economic stagnation. That will not require the skills implied.	1
S3.5	Job mortgages	Employee has to borrow money for education.	2

		This is not possible. If ordinary employee with a small entrance, then certainly major problems. Especially with family.	
S3.8	De-skilling	De-skilling is not the right term for me — probably there will be some narrowing and differentiation of skills, but sure a lot more new skills will be needed for the future — for both hi tech staff and lower paid production workers ... I mean with ICT rise in every aspect of life, who knows, probably the garbage picker and the toilet cleaning lady will need a special skills to operate with a 'smart' garbage bin or cleaning robot.	2
Public Attitudes			
S4.1	Attitudes to and awareness of risk	No awareness of risk. Aren't take up of new technology and new working patterns independent of attitudes to and awareness of risk? I can't clearly see this as a driver and am not aware of any clear trend either.	3
S4.3	Public attitude to (acceptance of) ICT developments	[No reason given.]	1
S4.4	The future of collective action	Ordinary small labour unions are certainly necessary.	2
S4.5	Rise in workplace cyberbullying	I don't believe that a rise in workplace cyberbullying would give rise to occupational health and safety concerns. On the contrary, with a digital world, the evidence of bullying is more readily available and therefore it should be easier to combat it in the workplace.	3
S4.6	Rise of the green lobby	No big impact neither influence.	1
Urban Environment			
S5.1	Increasing urbanisation	It is not sure whether this trend will continue. Solutions are developing.	3
TECHNOLOGICAL			
Pace of Change			
T1.4	Need for new standards	[No reason given.]	1

T1.6	Big Data	Beware data clog!	1
Autonomous Systems			
T2.1	Automation	These ideas are oversold.	1
T2.2	Robotics and collaborative robots	These ideas are oversold.	1
T2.3	Bionics	These ideas are oversold. Although there will be a significant advance in R&D in bionics, probably it will stay too expensive until 2025.	1
T2.4	Artificial intelligence	These ideas are oversold.	1
T2.7	Autonomous vehicles	Just because it's possible doesn't mean people will want them.	1
Advanced Human-Machine Interfaces			
T4.1	Augmented reality	Probably won't have a potential for large scale effect until 2025. Why bother with these?	2
T4.2	Virtual reality	Probably won't have a potential for large scale effect until 2025. Why bother with these?	2
T4.5	Direct brain to computer	It will take a long time. Probably won't have a potential for large scale effect until 2025. Why bother with these?	3
ICT Services and Infrastructure			
T5.2	Cloud computing	[No reason given.]	1
T5.3	Open intellectual property movement	Really? IP is a form of property and people will still want to make money from it. Big vested interests would have a lot to lose and will stop.	2
T5.7	Cybersecurity	I think it's more to be done with risk management from a business continuity perspective.	2
ECONOMIC			
Globalisation			
Ec1.1	Rising globalisation	Not necessarily so.	3

		Reactions against globalisation leading to protectionism. Will nationalism impede the growth of globalisation?	
Ec1.2	Offshoring	[No reason given]	1
Ec1.5	BRIC countries	Russia and Brazil are shrinking not growing.	3
Macro-economic Environment			
Ec2.1	EU growth since financial crash of 2008	I don’t see.	1
Ec2.2	Economic value of data	Trading data will work in specific contexts, but not many others.	1
Ec2.3	Insurance — low-risk companies may not insure owing to perfect data	Insurance will have a lot of new challenges to deal with — all the IoT, Alternative distribution chains, e-commerce, servitisation, P2P financing models, don't need insurance? Think again ;) I think insurance is highly important for every enterprise. I don't think so.	3
Ec3.1	Rise of micro-enterprises and small and medium-sized enterprises	Apparent growth of SMEs may reflect attempts of governments to collect taxes rather than new economic activity.	1
Ec3.8	Sub-contracting	[No reason given.]	1
New Business Models			
Ec4.1	Sharing economy	Naive idea.	1
Ec4.3	Servitisation	[No reason given.]	
	ENVIRONMENTAL		
Ev1	Climate change	I don’t see.	2
Ev2	Energy	Not big impact. One possible solution is the practical application in the technology of the possibilities of graphene, public institutions should support and fund this technology. More ICT has options that allow it to generate its energy on the spot; this could continue.	4

Ev4	Circular economy	[No reason given.]	1
Ev5	Disease	I don’t see.	1
	POLITICAL		
	Political Agenda		
P1.1	The European digital single market	Not so big impact.	1
P1.3	Security and privacy	I believe that the spirit of fraternity and political union is losing, only economic interests prevail.	2
P1.4	Investment in education and employment initiatives	Education is a priority for most parties in developed countries. Education will continue to be a priority. I don't see.	
P1.5	Control of migration	I don't see. The EU is not giving a coherent and unified response to this problem.	3
P2.2	Increasing geopolitical volatility	I don't see.	2

Appendix J: Description of consolidated trends and drivers

Table J1: Description of revised trends and drivers and their potential OSH impact

Ref.	Description of trend or driver	Potential OSH implications
Category: SOCIETAL		
Sub-category: Demographics and Characteristics of the Workforce		
S1.1	**Population changes** The global population is predicted to rise from 7,349 million in 2015 to 8,501 million by 2030. The International Labour Organization (ILO) states that 'current demographic trends bring 40 million people to the labour market each year, meaning that between now and the year 2030 the world economy needs to create over 600 million new jobs'. At the same time, the EU population is predicted to fall slightly from 738 million in 2015 to 734 million by 2030, along with a shortage of people in the active workforce. Global population change along with increased global mobility is expected to have a macro effect on the global industry structure, job market and the global availability of jobs.	OSH interventions may need to be similarly more diverse in order to be suitable for a diverse workforce. It may be difficult to manage the workforce owing to the diversity of teams, as there may be more conflict when there is a wide range of experience, viewpoints and expectations about OSH.
S1.2	**Ageing workforce** Consistently low birth rates and higher life expectancy will transform the age profile of the population. Although the median age is rising everywhere in the EU, there are variations across the EU, between 36.0 years in Ireland and 45.6 years in Germany. Countries looking to join the EU have lower median ages. Retirement age is expected, as a consequence, to continue to rise, so there will be many more elderly workers, including an increase in the proportion of older women in the future, with increased age diversity within the workforce. It is expected that having as many as five different generations in the same workplace will increasingly become the norm.	An ageing workforce is likely to cause a rise in the number of workers with multiple chronic and complex diseases that will need to be managed in the workplace. Better systems may be needed for assessing and implementing work adjustments that can be transferred from one job to another. New HR and management processes may also be needed to sensitively screen people in safety-critical jobs or jobs that may exacerbate their condition. There may be a need for career advice aimed at older as well as young people in order to assist with career development, career choices/changes and associated retraining. Different generations are likely to have different characteristics, values, expectations and needs in terms of OSH management. Some experts believe that generally after the age of 75 individuals begin a slow and difficult decline, where both productivity and creativity are reduced.

	There may be a future rise in the 'tapered retirement' model, where an employee slowly reduces their duties as they approach retirement, through part-time work or self-employment. This has also been described as 'bridge employment'. Most European employees now expect to be working beyond their state's official retirement age. One in five non-retired people in the United Kingdom think they will never retire, and of those who do think they will retire just over four in ten feel that they will continue to work at least part time.	However, there is no real research on post-65 workers. An older workforce may be less physically agile with slower reaction times. However, some experts believe that older workers have coping mechanisms that overcome these limitations up to a point. These could include the use of ICT-ETs. Depending on the nature of work, it can have either a positive or a negative effect on physical and cognitive decline, health and life expectancy (including healthy life years). Those that follow a tapered retirement model have been found to experience fewer major diseases and be able to function better day-to-day than people who stop working altogether. An ageing population will place increased demand on the healthcare sector.
S1.3	**Increasing migration into the EU** This is likely owing to ongoing or increasingly large differences in standard of living between countries and refugees from conflict, as well as the use of mobile devices providing ease of access to information about different countries and travel options.	Workplaces are likely to become increasingly diverse in terms of ethnicity and nationality. OSH interventions may need to be similarly more diverse in order to be suitable for a diverse workforce. There may be new challenges for OSH management due to the diversity of teams and the wide range of viewpoints and expectations about OSH. There will also be language barriers *One respondent to the first web survey expressed concern about segregation and alienation due to the influence of the media and negative attitudes surrounding immigration, such that many workplaces now find that they have internal segregation of workers or workplace discrimination — i.e. foreign workers are not socialised with, or are discriminated against.*
S1.4	**Generational differences** While there is considerable diversity within different generations, it is thought that there are some common behaviours that can be attributed to the different generations currently in, or about to enter, the workplace. *Generation Z — 'digital natives'* This generational cohort (born 1995-2009) is beginning to enter the workplace. They tend to spend a lot of time online, as they were born and grew up in a digital, connected world and are more digitally minded, hence 'digital natives'.	Generation Z is more likely than others to adapt to more flexible, collaborative and online working patterns. They may be less tolerant to using dated ICT technology at work. This may cause conflict with earlier generations, who are likely to have seniority. However, it is also probable that workers using their own ICT devices at work will become the norm — so-called bring your own device (BYOD) arrangements. This could potentially make corporate management and protection of commercial and personal data more difficult. It could also make hacking into organisational systems easier (see T5.7, 'Cybersecurity'.

	As well as being digitally minded, they tend to be more individualistic, entrepreneurial and creative. They generally have no problem interacting with people online whom they have never met. They tend to desire lifelong learning and are more likely to seek 'portfolio careers' rather than a 'job for life'. They prefer one-to-one and face-to-face communication. Their other expectations include wanting their job to have an impact on society and the world and having to work harder than earlier generations. Generation Z are more inclined to participate in the 'sharing economy'. *Generation Y* Born between 1979 and 1991, they account for about 27 % of the workforce. Approximately half have spent less than three years with their current employer. Most are likely to be either knowledge or service workers. Readily available technology has played a big role in shaping this generation. Generally, this group wants more autonomy, more control over working hours and development opportunities. They likely view their career more as a 'scramble net' rather than as a ladder. *Generation X, baby boomers and veterans* Owing to changing retirement patterns, baby boomers who are coming up to retirement age are less likely to retire. In part as a result of changes in retirement law and/or the financial crash and reductions in the value of pensions, so-called veterans are continuing to work, either because they still wish to or because they need to for financial reasons. They are more used to a hierarchical management style and less autonomy; they have not grown up in a digital world and ICT may still be thought of as a new innovation in the workplace.	Generation Z are likely to create the initial increased demand for online app-facilitated shared-asset platforms. Owing to a more sedentary online lifestyle, workers in Generation Z may have lower fitness and be more susceptible to chronic health problems (e.g. type 2 diabetes, cardiovascular disorders or MSDs). Owing to the variety of jobs a worker in Generations Z and Y may have, it may be more difficult for employers to manage their OSH needs or for good records to be kept about their occupational exposure to health hazards. This can make prevention of work-related diseases and tracing the causes of work-related diseases when they occur difficult. However, the use of open cloud data may facilitate keeping of better records. There may also be a need to develop different ways to communicate OSH messages to Gen Z'ers (e.g. ICT-based or collaborative approaches). Increased staff turnover among Generations Z and Y could lead to a loss of corporate memory of OSH incidents and OSH controls, which could in turn increase the risk of major accidents and work-related diseases. Baby boomers and veterans are less likely to be comfortable using ICT. They, like Generation X, are also likely be more suspicious and concerned about the security of their information. How they adapt and view Generations Y and Z will be a key issue in managing OSH in the multigenerational workforce of the future. Existing management and leadership styles may be a barrier to managing the OSH needs of a wide range of competencies, both between and within occupational groups. The diversity of attitudes and behaviours associated with a multigenerational and multicultural workforce will also make managing OSH more difficult.
S1.5	**More women in the workforce** The number of women working has risen progressively over the last several decades. Today, in almost 100 countries	Generally this means that both partners work, so there will be a greater need for individuals to be able to balance work and home life; this will lead to demand for more flexible working arrangements.

	women make up the majority studying at university.	Part-time work continues to be a predominantly female domain and there has been an increase of 25 % in freelancing mothers in the last two years.
S1.6	**Increasing number of workers with chronic and complex health problems** (including MSDs, cancers, mental health disorders, etc.) and the need for more inclusive and adapted workplaces, increased incentives at policy level and awareness-raising initiatives.	An ageing workforce is likely to experience a range of diseases and disorders associated with increasing age, such as cancer, atherosclerosis (arterial-disease), cardiovascular disease, cataracts, arthritis, type-2 diabetes, hypertension, osteoporosis, Alzheimer's disease and increased risk of MSDs. Therefore, an increasingly older workforce is likely to experience one or more of these health issues while at work. The generation of workers now entering the workforce is less active than previous generations; this means that these workers may have an increased risk of health conditions such as MSDs, high blood pressure and type 2 diabetes. Digital technologies and the 'always on' 24/7 society have the potential to create stresses and pressures that could exacerbate existing (mental health) disorders or create new ones. However, there are also a range of digital products, such as smartphone apps, that can help treat, for example, mental health conditions. Research has also recently found that the mental health of those in poor psychosocial quality jobs was equivalent or worse than those who are unemployed. These health issues may require employers to make significant workplace adjustments to enable workers to continue to work.
S1.7	**Increased inequality and polarisation** There are strong indications that the benefits from technological innovation will not be spread evenly across society, and there will be disparities of access between socio-economic groups. *One interviewee also pointed out that the poor offline ability of ICT was a problem in rural communities and industries such as mining, where access to the internet is poor. This could create inequality for these communities.* ICT developments can affect the skill distribution of employment. There is a large increase in workers at the bottom of the scale and a reduction in workers at the top of the scale, with a shrinking middle class (resulting in the loss of medium-skilled jobs).	The workforce will have differing competences in relation to their understanding and awareness of OSH. There is a danger of an inappropriately skilled workforce, which may lead to potential OSH risks. This inequality and polarisation could lead to social unrest and increased migration from poorer countries, which may also have an impact in terms of lower levels of OSH awareness.

	There is also the risk of the rise of a 'digital elite', with good ICT and other skills; this group prospers as others are left behind. There are indications that these trends will continue. Rising inequality is expected to limit earning prospects for a large proportion of the future workforce. It is likely to become increasingly harder for governments to invest in education and employment initiatives owing to competing demands for expenditure on, for example, pension payments, social security and interest on debts. If the costs of education are increasingly borne by individuals, then less affluent individuals will be unable to get the necessary skills to obtain a good-quality job. Countries that have higher income inequality will suffer the most in terms of quality of education and job opportunities, and so the inequality will become self-perpetuating.	
Sub-category: Employment Patterns		
S2.1	**Flexible working patterns** New forms of flexible working are becoming more widespread. These include flexibility in working hours, part-time or zero-hours contracts, home or mobile working, crowd-work, shorter term temporary contracts, self-employment and sub-contracting. Since the global recession, the number of people working regular night shifts has increased to more than 3 million, in the United Kingdom alone (14.9 % of men and 9.7 % of women), with the possibility that this proportion will continue to rise. In 2010, almost 18 % of EU workers did at least one night shift per month, but there are indications that this number may be falling in the EU. A sizeable and growing minority of workers are now in some form of atypical employment (including involuntary part-time and temporary working, and less secure self-employment).	Employment and social security laws may not have the required flexibility to cope with these changes in working patterns. This means that a significant minority of vulnerable workers may find their jobs insecure, unprotected and low paid, without proper safety nets in place. This precarious employment can lead to stress and ill health, as workers may not able to properly look after their health as they move from one geographical location to another in search of their next contract. Increasingly blurred boundaries between work and personal life can lead to a perceived or real need to be available to work colleagues 24/7, resulting in a lack of sufficient down-time and potential for burnout. Globally, around 50 % of individuals claim to have an urge to monitor work emails at home. Individuals in the United Kingdom, Spain and Germany under the age of 35 are twice as likely to experience anxiety being away from their electronic devices than those over 35. This has been referred to as 'technostress'.

	Those who work in part-time, temporary and contract jobs, or are self-employed, have been referred to as 'on-demand workers', and their numbers are anticipated to double by 2020. There are indications that the number of people on zero-hours contracts is showing a continuing upwards trend and that the people on them are most likely to be either under 25 or over 65. By 2030, as many as half of all workers could be on zero-hour contracts. Workers may have many different jobs during a career or several careers in a working life. Insecure work is more likely to be done by younger rather than older workers; however, they are less likely to be worried about job insecurity than older workers. *One interviewee also pointed out that workers now tend to have to provide their own equipment, often referred to as BYOD — bring your own device.*	Flexible working patterns offer benefits to employers and also to some employees, such as those wishing to reduce their hours as they approach retirement, or those who want to balance work with caring responsibilities, leisure, sport or education. There is growing evidence that the shift to more precarious flexible working patterns weakens the effectiveness of regulatory oversight and can undermine OSH surveillance systems as workers become harder to reach. In addition, a substantial body of research has linked job insecurity and the growth of precarious employment to poorer OSH outcomes. Shift working disrupts sleep patterns and can lead to exhaustion, mental health problems and other health issues. Shift working, for example, has been linked to increased risk of certain cancers, particularly breast cancer in women working night shifts. Other reported health problems are colitis, gastroduodenitis, peptic ulcers, hypertension and ischaemic heart diseases. About 20 % of all workers have to stop shift work altogether after a very brief period because of serious health problems Owing to the variety of jobs a worker may have, it may be more difficult to manage their OSH needs or for good OSH records to be kept. However, the use of more open cloud data may facilitate the keeping of better records. Increased staff turnover could lead to a loss of corporate memory of OSH incidents and OSH controls, which could in turn increase the risk of accidents and diseases. *One interviewee expressed a concern that so-called BYOD can create issues of security and consistency.* *Another respondent to the web survey asked 'Will future employment be able to provide most workers/employees with sustainable incomes, i.e. can you make a living and generate savings with a 40 hours/week job?'*
S2.2	**Virtual workplaces** With the ever-increasing proliferation and ubiquity of mobile broadband, individuals can work in almost any location at any time. It has been predicted that within 20 years more than a billion new online workers will enter the job market globally.	The virtualisation of the workplace is being driven by an increasing pace of ICT technological developments. This can result in: - a removal of the boundaries between work and home life; - increasing virtualisation of work relationships; - fear of missing out (FOMO);

	This has created a positive feedback loop. As ICT makes it easier to work anywhere, the demand to be able to do so increases, as does the demand for the ICT to improve, which then makes it easier to work in this way, thus creating more demand. As the number of people working in this way grows, so does the market, which generally reduces the costs of the technology, making it more accessible to more people. Cloud technology also allows workers across the world to work together by sharing data and information. The workplace can therefore be at home, while travelling, in any public place where there is WiFi and geographically distant from the location of the employer. The workplace is increasingly expected to be replaced by a 'virtual workspace'. It is predicted that this is likely to create a project economy, where jobs and organisations become increasingly fluid. Currently, close to half of workers who work in this way are aged between 26 and 35.	- confusion between what is urgent and what is important. All the above can lead to OSH risks, including increased work-related stress, social anxiety or burnout. In addition, people working in different time zones from their colleagues can result in a need to be available at unsociable times of the day in order to collaborate. It is likely that the intensity of work will increase in the absence of supervised work schedules or working hours, which may lead to stress and burnout. Workers will need to develop better skills for managing and organising their workloads to create a good work-life balance that supports well-being. Virtual workplaces can allow employees, such as those wishing to reduce their hours as they approach retirement, or those who want to balance work with caring responsibilities, leisure, sport or education, to work the hours they want. Conversely, it can provide access to work for people who might not otherwise be able to work. This may lead to a surplus in the job market and potentially consequent job insecurity, low pay and working conditions. *One respondent to the web survey asked 'Will future employment be able to provide most workers/employees with sustainable incomes, i.e. can you make a living and generate savings with a 40 hours/week job?'* Employment and social security laws may not have the required flexibility to cope with these changes in working patterns. There is also growing evidence that the shift to more precarious working patterns weakens the effectiveness of regulatory oversight and can undermine OSH surveillance systems as workers become harder to reach. This means that a significant minority of vulnerable workers may find their jobs insecure, unprotected and low paid, without proper safety nets in place. A substantial body of research has linked job insecurity and the growth of precarious employment to poorer OSH outcomes, including stress and ill health. It may be difficult to manage the workforce owing to the diversity of teams, as there may be more conflict when there is a wide range of experience and viewpoints. Owing to the variety of jobs a worker may have, it may be more difficult for good records to be kept about their exposure to health hazards, although the use of open cloud data may help facilitate better OSH record keeping.

		Workers are increasingly likely, under this model, to use their own devices for work, potentially making corporate management and protection of commercial and personal data more difficult.
S2.3	**Crowd-working** Increasingly, online platforms are being used to enable organisations or individuals to access an indefinite and unknown group of other organisations or individuals to solve specific problems or to provide specific services or products in exchange for payment. New online 'talent cloud' apps that match work requirements to workers' skills and interests are emerging, such as 'Task Rabbit'. The total number of 'cloud-workers' globally doubled in just one year between 2010 and 2011, and revenue created by this kind of working increased by 75 %.	This workforce is highly diverse and poorly defined. Employment and social security laws may not have the required flexibility to cope with these changes in working patterns. There is also growing evidence that the shift to more precarious working patterns weakens the effectiveness of regulatory oversight and can undermine OSH surveillance systems as workers become harder to reach. As online work exchanges take multiple forms and are therefore difficult to categorise, there are also open questions about the status of crowd-workers (e.g. are they employees or self-employed workers/freelancers?) and who the employer is, as well as related open issues involving OSH responsibility, insurance and legal liability. This means that a significant minority of vulnerable workers may find their jobs insecure, unprotected and low paid, without proper safety nets in place. A substantial body of research has linked job insecurity and the growth of precarious employment to poorer OSH outcomes, including stress and ill health. Psychosocial risks may arise from a variety of working conditions typical of crowd-sourced employment, but the traditional job content/context model does not apply to these new forms of work, and standard preventive measures may not be applicable. For example, people may be working at locations in different time zones from their colleagues, and this can create a need to be available at unsociable times of the day in order to collaborate. It is also likely that the intensity of work will increase in the absence of supervised work schedules or working hours, which may lead to stress and burnout. Workers will need to develop better skills for managing and organising their workloads to create a good work-life balance that supports well-being. It may be difficult to manage the workforce or provide suitable OSH training owing to the diversity and remoteness of teams. There may be more conflict when there is a wide range of experience and viewpoints. Owing to the variety of jobs a worker may have, it may be more difficult for good records to be kept about their exposure to health hazards. However, the use of open cloud data may facilitate better OSH record keeping.

		Workers may be working using devices or in locations that are not suitable ergonomically, leading to musculoskeletal problems. Workers may also be unable to afford (or unaware of the need for) eye tests and the use of suitable lenses for screen work, leading to visual strain and attendant problems such as headaches.
S2.4	**Fluid co-working spaces** These are shared physical workspaces where individuals work who are generally not employed by the same organisation. Companies are increasingly reducing their office space and creating or using shared spaces to maximise productivity. Co-working has recently emerged as one of the fastest-growing trends, with the 'workspace' slowly replacing the workplace. Across the world, the number of places for co-working has approximately doubled every year since 2006. These co-working spaces are designed to accommodate a more flexible style of working, and might include meeting rooms and hot desks in order to meet the variable needs of organisations and individuals. They aim to facilitate the sharing of ideas and contacts in a relaxed, yet professional, atmosphere	Some workers may like more flexible shared workspaces, whereas others may find it stressful not having their own personal space at work. OSH may be more difficult to manage owing to constant change in who is using the space. It could also be unclear who is responsible for OSH in these places, for example whether it is the owner/manager of the space or the employer(s) of the workers using the space.
S2.5	**Changes to HR management** The opportunities presented by ICT, increased remote working and the drive to improve productivity create two very different new styles of HR management. This can range from increasing worker surveillance and monitoring by data profiling to flatter organisational structures where workers are supervised less, have more autonomy and are judged by innovation as well as output, rather than just time spent at work	Increasing workplace monitoring and screening can mean that the privacy of workers is eroded. The perception of monitoring can lead to worker stress and a lack of job security. Generation Y, which accounts for over a quarter of the workforce, and Generation Z, which is now entering or about to enter the workplace, are least likely to cope well with increasing worker surveillance. Both of the HR management methods identified can lead to the intensification of work, which may increase the workload too far. Flatter organisations mean that workers have more autonomy and control, which may improve job satisfaction and well-being for some and create a feeling of lack of support for others.

S2.6	**Shift working** This has been merged with S2.1, as it is one of the earliest forms of flexible working.	
Sub-category: Skills		
S3.1	**Increases in basic ICT skills** There is expected to be an increase in the global population's basic online skills in the future, for a range of reasons including the improved ICT skills of the younger population, the decreasing cost of internet use and larger numbers of online services. Basic ICT skills are, however, expected to vary significantly between countries.	Provision of online OSH guidance and training is likely to be well utilised and increasingly effective. *This will have an advantage, mentioned by one interviewee, namely that 'apps are a better way of giving people OSH information than manuals'.*
S3.2	**Gaps in ICT Skills** The pace of change in ICT means that there is a need for many more people with higher level ICT skills in the workforce, including literacy, numeracy and collaboration. Currently, these are lacking, and there are significant differences between countries. Moreover, as technology advances and changes, digital skills will become outdated more quickly. Demand for ICT skills in Europe is increasing by 4 % every year and projections indicate that 900,000 ICT jobs will need to be filled by 2020. A study of all of the 361 Standard Occupation Codes, covering 30 million people employed in the United Kingdom, showed that as ICT becomes more pervasive 93 % of the workforce will, in the future, need the ability to use ICT to do their job. Declining numbers of people studying science, technology, engineering and mathematics (STEM) topics in education will perpetuate the gap, as skills in these areas will become increasingly important as technology becomes more pervasive and complex.	A lack of appropriate skills could lead to an increase in OSH risks as a consequence of poor OSH awareness and inadequate OSH training. With the need for frequent retraining, MOOCs may enable the digitisation and modularisation of education and training. The application of analytics to better measure learner patterns should help improve the quality of MOOCs.

S3.3	**Advanced reasoning skills** As automation, AI and robotics increasingly penetrate the workplace, advanced reasoning skills, including problem solving, judgement under uncertainty, creativity, and interpersonal and emotional intelligence will become increasingly important. This may lead to requirements for higher skill levels for entry-level positions. There is evidence that the staff of successful digital companies have both technical and creative skills and that increasingly employers want creative skills as well as technical skills.	These types of reasoning skills are also important for effective management of OSH risks, particularly when faced with uncertainty and conflicting information, viewpoints and stakeholder needs. Moreover, these skills enable workers to better respond during non-routine situations (e.g. malfunction of an automated system) that could potentially be precursors to a major accident.
S3.4	**Lifelong learning** Owing to the high pace of change in the workplace and extended working lives, people are increasingly likely to need retraining several times during their careers. It is also increasingly difficult for school leavers to know what to study in further or higher education because they do not know what skills they will need by the time they finish the course.	There may be an increasing diversity of knowledge and understanding of OSH in the workforce, making it difficult for employers to properly manage OSH.
S3.5	**Job mortgages** Owing to changing working patterns, workers are likely to have to take increasing responsibility for their own training. This may include workers borrowing money to cover the cost of training against their future potential earnings.	As employees take more responsibility for their own training, there may be an increasing diversity of knowledge and understanding of OSH in the workforce. It may become difficult for managers to keep a record of OSH training that employees have received, making it difficult for employers to properly manage OSH. However, the cloud may help store reliable data on education, qualifications, training and experience that can be taken from one job to another.
S3.6	**Quickening pace of knowledge transfer** This trend is driven by instantaneous global communication and beneficial for skills transfer between workers.	This could enable the instant, global sharing of OSH information.
S3.7	**Access to online education** An increasingly networked world could allow close to universal access to virtual learning. Collective intelligence could also complement individual intelligence.	This could improve OSH by allowing experience and intelligence to be shared between workers and organisations. It would also facilitate greater OSH collaboration, increase awareness and improve management of OSH.

	MOOCs can digitally duplicate the best teachers, including their methods and course materials, making them available to thousands or more people. The digitisation of education also allows analytics to better measure learner performance.	MOOCs could lead to more effective OSH training and learning globally. However, there will be a need to ensure the quality of OSH training delivered in this way. The potential for more effective skills training could lead to a reduction in OSH risks through increased awareness and better management. However, some concerns have been raised about whether this method is of significant educational quality compared with face-to-face interaction.
S3.8	**De-skilling** In some occupations, jobs may become de-skilled as the role of the worker becomes more akin to that of a machine operative as a consequence of, for example, increased use of automation, machine learning and AI.	There is a danger of an inappropriately skilled workforce, which may lead to potential OSH risks. They may, for example, be less likely to be able to respond appropriately when something unexpected occurs, such as a malfunction, which could be a precursor to an accident.
Sub-category: Public Attitudes		
S4.1	**Attitudes to and awareness of risk (all relevant stakeholders)** How people perceive risks is affected by trust in the organisation seen as being responsible for managing that risk, whether the risk is commonly framed negatively or positively by those, including the media, who communicate it. Moreover, another factor is whether the technology is associated with what are referred to as 'fright factors', for example whether any harm is perceived to be irreversible, unnatural, imposed, uncertain or inequitable. For example, the fear of AI becoming self-aware and wiping out humanity in the future could hold back advances in this field. Those risks that people choose to accept or worry about are often cultural and can vary between different countries. This can be affected by the perceived usefulness or status associated with the technology or what is seen as normal behaviour in terms of technologies that are used.	People's acceptance of technology will be affected by their perception of any risks associated with it. Whether workers adopt safe behaviours when using technology is also affected by whether they are aware of risks, whether they are worried about those risks and whether the inconvenience caused by the prescribed safe behaviour outweighs the perceived benefits of reducing the risks. Whether risks are properly managed is affected by the identification and understanding of them by employers and managers, employees, regulators and other stakeholders.

S4.2	**Attitudes to online privacy** Issues such as online privacy and the security of data are an increasing concern. As internet-enabled devices become smaller and more pervasive (e.g. wearables), data collection becomes less obvious but more comprehensive (e.g. user activities and location information currently collected by smartphones). Attitudes to privacy vary, but most people are happy to provide their data for the sake of convenience. Technologies to allow anonymity online are increasingly available and used, and encrypted online data traffic is rising: 10 % of current levels are encrypted.	In the workplace, concerns over the collection of data on productivity and attendance can lead to A feeling of job insecurity and stress due to the real or perceived need to work faster and faster.
S4.3	**Public attitudes to (acceptance of and demand for) ICT developments and ethics** Major developments in ICT in relation to work will be dependent on the acceptability of the technology to the public; for example, both France and Belgium have started a public debate on ICT developments. The initial results indicate that generally technology is considered OK, unless it is considered a threat to the social model. Innovation is currently driving increasing global demand for products such as luxury electronic devices (e.g. high-end mobile phones) and 'green energy'. This trend is expected to continue. *Interviewees and respondents to the web survey also pointed out that acceptance of and demand for ICT developments could be influenced by fashion, as well as an increasing dependence on ICT-ETs and/or a reduced tolerance towards commuting, for example caused by traffic congestion. Several interviewees also pointed out the importance of ethics, suggesting, for example, 'putting social scientist on every technology team to think about the impact on people [and] … the ethics'.*	Public attitudes may hinder the progress of ICT technologies. This may also affect the use of ICT technologies for OSH purposes, such as personal exposure monitoring. An increased global demand for luxury electronic devices and green energy is likely to drive ongoing ICT developments and growth in emerging industrial sectors. OSH risks may rise in association with an expanding workforce in these sectors, as workers are likely to lack experience. If a workforce expands rapidly, it is also difficult to provide sufficient experienced staff for adequate supervision and training. *An increased demand for ICT developments can, as one respondent to the web survey put it, lead to a 'continuum of obsolescence of the worker'.*

S4.4	**The future of collective action (Trade Unions)** The level of trade union density across the EU is an average of 23 %. However, it varies greatly, for example from as high as 70 % in Denmark and Sweden to as low as 8 % in France. However, in recent years, in most EU countries, union membership has continued to fall. In addition, even when union membership has grown, it has not maintained pace with the growth in the proportion of people employed. With new jobs and forms of employment, trade unions as we know them may cease to exist in the future. However, online platform-based alternatives may spring up, akin to online petitions/lobbying, Facebook or other social media-based groups.	If trade union membership continues to fall, or ultimately trade unions cease to exist, this is likely to have a negative effect on OSH, as unions will have fewer numbers and lack the resources to campaign for improved health and safety at work. There is good evidence that worker involvement improves OSH, and such involvement is often facilitated by trade unions.
S4.5	**Discrimination, violence and bullying** The rise in social networking has brought about a corresponding ongoing rise in discrimination and bullying (this includes anonymous cyberbullying). Recent academic research has shown that cyberbullying at work is becoming as common as non-electronic forms of bullying.	Cyberbullying and online discrimination could be seen as a form of workplace violence, and can cause work-related stress, anxiety, time off work and mental health issues.
S4.6	**Decarbonisation, green targets and sustainability** There is an increasing awareness of and campaigning for green issues and sustainability, putting pressure on organisations to respond. Most will have some form of carbon emission reduction policy in place. These often cover travel, use of natural resources, for example through paper creation, and recycling of waste.	May drive demand for ICT-enabled alternative working patterns, in particular use of ICT to reduce travel and to store data.
Sub-category: Urban Environment		
S5.1	**Smart cities** The increasing pace of ICT developments, such as in Big Data, the Internet of Things, high-speed interconnectivity, wireless networks and social media, will probably facilitate the development of smart cities, affecting commuting and work environments.	Autonomous technologies and data feeds may lead to predictive maintenance and inspection of public infrastructure and services, which will improve OSH for those using the services and also for those maintaining them.

		The increasing interconnectedness of city infrastructure and devices could mean that a failure could cause a cascade of further failures affecting a wide range of infrastructure and services, which could have implications for the OSH of the workers providing the services, for example workers in hospitals, schools, transport, waste collection and supply of utilities.
S5.2	**Increasing urbanisation** Individuals are increasingly moving to cities to work, and this trend is set to continue over the next decade. The urban population of the world is rising at the fastest rate in history. Global urban populations are projected to increase from 2.6 billion in 2010 to 5.2 billion by 2050.	This brings potential for increased work intensification, urban stress and stress from crowded workplaces.
Category: TECHNOLOGICAL		
Sub-category: Pace of Change		
T1.1	**Technological advances in ICT** With technology advancing on many fronts — not just in ICT, but also in biotech and materials science — there will be pervasive effects across a wide range of areas. These may be amplified where two or more areas combine. Developments in NBIC — nanotechnology, biotechnology, information technology and cognitive science (AI and brain sciences) — are advancing and converging. Discoveries in one area may progress developments in another area. This combined effect can increase the power of research that has the potential to bring about significant technological advances or lead to new technological fields. An example is the development of thought-controlled bionic arms, which were created by combined advances in cognitive science, robotics and ICT.	This drives increased use of ICT and underpins many of the other drivers described above and below. Therefore, while there are no OSH risks specific to technological advances per se, they contribute to all the associated benefits and risks specific to many of the other drivers listed elsewhere. *Such advances can, as one interviewee put it, create 'increasing huge complexity in modern computer systems'.*
T1.2	**Advances in computing power and speed** Moore's Law, which states that the number of transistors on computer processors will double every two years, has been remarkably consistent — so far. Computer power is continuing to increase exponentially.	This drives increased use of ICT and underpins many of the other drivers described above and below. Therefore, while there are no OSH risks specific to technological advances per se, they contribute to all the associated benefits and risks

	Computers are becoming ever more powerful, increasingly reducing in cost and getting smaller. Continuing enhancements to computer speed are expected to need new types of transistor. The time to develop these could potentially slow down the rate of computer progress in the future One major leap could come through quantum computing, which is now beginning to find applications. Fibre optic and 5G communications systems offer the prospect of ever-increasing bandwidth.	specific to many of the other drivers listed elsewhere. In addition, the increase in computing power may lead to workers having to work harder to keep up (work intensification); for example, while people never felt they needed to respond quickly to a letter, they feel that they do need to reply quickly to an email on a computer and instantly to one on a mobile device.
T1.3	**Technical challenges for ICT** The electromagnetic spectrum is a limited resource and could be a constraint on the exponential increase of devices requiring internet access. Reductions in the availability of sources of energy may hinder future developments of ICT. If progress in the development of the smart grid is too slow, this may also hinder ICT advances. Continuing enhancements to computer speed are expected to need new types of transistor. The time to develop these could potentially slow down the rate of computer progress in the future. Some experts believe that advances in chemistry are needed to significantly advance ICT technologies. Battery charge life is lagging far behind developments in computer processing power, and in the next five years or so the performance of lithium ion batteries is not likely to radically improve. Many institutions and companies are carrying out a great deal of research into new materials and processes. In the longer term, new battery technologies could emerge that harvest energy, for example from vibration. *Other challenges: one raised by several interviewees was 'stability of legacy computer systems' and another raised by a respondent to the web survey was 'poor offline ability (e.g. rural, mining)'.*	These are likely to bring new challenges for OSH, including new potentially unknown hazards. There have been a number of documented fires related to, for example, lithium ion batteries and sodium sulphur batteries used for electricity grid levelling. High-capacity batteries will also pose an electrocution risk. Batteries often contain hazardous materials or the material may be at high temperature, so they may pose health risks due to exposure from a leakage if the battery fails, during manufacture or during refurbishment and recycling activities.

T1.4	**Need for new standards** There are many, and will be many more, different technological devices that need common standards to enable them to 'talk' to each other. A lack of common standards may limit ICT advances.	Standardisation processes are an opportunity to embed and integrate good OSH practices.
T1.5	**Internet of things** The potential for vast numbers of cheap sensors taking measurements opens up a wealth of possibilities for machine-to-machine (M2M) communication and pervasive sensors, especially when combined with Big Data analytics and machine learning. In 2015, there were 15 billion devices connected to the internet. Cisco predicts that, by 2020, worldwide there will be around 50 billion devices connected and gathering data. Examples of applications include logistics, tracking deliveries; 'smart countryside' — monitoring and control of irrigation, fertiliser and weedkiller; 'smart roads' — monitoring road conditions; personal environmental monitoring — tracking exposure to air pollution.	An increasingly sensor-connected world will result in benefits for OSH, for example improved safety of physical processes through better monitoring and control. Personal exposure monitoring of toxic substances could be facilitated by the use of smart sensors incorporated into wearable devices. Increased ability to monitor and track OSH interventions has the potential to better enable evaluation of them and lead to more effective interventions. However, this ability could also be used to increasingly monitor the performance and attendance of individuals, which raises issues of data protection/privacy and the use of data to discriminate against some workers. This has the potential to cause stress. Owing to the complexity of the data, workers may lack understanding of what data are collected, for what purpose, etc. leading to feelings of lack of control of one's data, insecurity and stress. Increasingly integrated, complex systems may result in undesirable properties in terms of OSH. Increasingly integrated, complex systems may mean that a failure in one system has the potential to cascade through other systems; for example, in a safety-critical system, this has potential implications for safety. The Internet of Things does makes organisations more vulnerable to cyber-attacks, with potentially serious OSH implications.
T1.6	**Big Data** This is a combination of three trends. **Increasing rate of data generation:** increasing levels of global connectivity and networking are driving the generation of vast amounts of data; this growth in data production continues to rise over time. For example, 12 terabytes of data are produced daily as Twitter 'tweets'. Currently, there are approximately 1 trillion sensors producing data.	Increased availability of information-rich data could allow a vastly improved analysis of historical and current OSH-related data to improve health and safety. For example, management and analysis of data in digital form may mean that OSH regulators can easily investigate breaches. In addition, businesses can more easily demonstrate compliance with OSH standards and regulation.

	Projections show that data generation will have risen by 2,000 % in 2020, compared with 2015 **Improving data storage:** since 2005, globally the level of data stored has doubled around every two years; in some areas, the volume of data is increasing at a faster rate than it can be processed and studied. Data storage costs are also decreasing at an exponential rate. **Advancing data analysis:** new analytical techniques are being developed for managing large data sets and deriving new insights into behaviours.	Businesses are increasingly analysing their data in order to make their work processes more efficient; this could ultimately lead to work intensification. For example, a computer algorithm to improve order-picking efficiency may put significant physical and psychosocial demands on workers; this, in some cases, has led to exhaustion, physical injuries and increased stress and other mental health disorders. Data sets, such as on chemical plant operations, could be traded to improve OSH experience and share knowledge; this could lead to predictive asset management, for example Level 2 Building Information Modelling (BIM), where data are shared between building operators, tenants, contractors and designers. In order to do this, there need to be standards to ensure the quality, reliability and interoperability of data used. This may require regulation, as operators may need to be incentivised to do this. There will also be a need to have effective and efficient systems and strategies to be able to deal with the very large volumes of data and understand what data to look at, analyse and store for the future. There is also the danger of the misuse of Big Data to the disadvantage of individuals or governments. There are also the issues of data protection/privacy and the use of data to discriminate against workers. In addition, for workers, the complexity and a lack of understanding of what data are collected and for what purpose could lead to feelings of lack of control of one's data, insecurity and stress.
T1.7	**User-centred design (new)** Often, ICT products and systems are designed with a focus on features, technological capabilities (hardware and software) or business aims, rather than on the end-user or workplace. This means that users need to adapt their behaviours and attitudes to use the product or system, which in some cases can cause frustration or ultimately stress. User-centred design aims to create a product or system that supports the user's behaviour and attitudes. If technology is designed with the end-user's needs and OSH in mind, then it is more likely to be widely and successfully adopted.	A user-centred design approach also tends to lead to improved design for OSH. If OSH is taken into consideration during design, then problems do not occur and there is no need for remedial action to solve OSH problems

Sub-category: Autonomous Systems		
T2.1	**Automation** Automation of manufacturing processes has been around for some time. However, there is increasing interest in automating many other types of work. Any activity that is characterised by being repetitive, routine, structured and rules-based is likely to be automated over coming decades.	This removes the need for people to carry out activities that can cause injury and ill health as a result of exposure to a variety of hazards such as repetitive strain, entanglement with moving machinery, dust, toxic chemicals, electricity, etc. Low-skilled workers are likely to be squeezed out of the job market by machines and potentially into more precarious types of employment, which could lead to poorer OSH outcomes.
T2.2	**Robotics and collaborative robots** Advanced robotics promises a world with limited need for physical labour. Robots are becoming capable of carrying out ever more intricate tasks and of operating alongside people. They are also operating in an increasingly autonomous and self-learning way. In advanced economies, most manual labour could potentially be automated away. This will impact on the skills required in the workforce.	Although there will be OSH benefits from increased robotisation, by removing workers from hazardous environments, collaborative robots, which work alongside or with workers, may pose a risk of injury from being struck by the robot. Although some collaborative robots are slow and lightweight, which minimises injury potential, the next generation are expected to move faster and with greater force and may, therefore, pose an increased risk to workers. As well as replacing people in difficult, strenuous or hazardous environments, robots can assist humans, for example by lifting patients, thereby reducing the risk of injury. Low-skilled workers are likely to be squeezed out of the job market by machines and potentially into more precarious types of employment, which can lead to poorer OSH outcomes. If people work collaboratively with robots, they may be placed under pressure to perform at the speed of the robot. Robots may in the future be in charge of work schedules. Workers' bosses may even be 'robot-bosses'. This could result in workers trying to achieve very high efficiency demands placed on them by a robot that does not understand that humans cannot work at maximum efficiency all the time. This could lead to psychosocial issues such as work intensification, stress and exhaustion, and to an increase in the use of performance-enhancing drugs in the workplace.
T2.3	**Bionics** Robotic-based technologies can be used to augment human activities and strength or to overcome disabilities, for example through exoskeletons.	There are obvious benefits for OSH in the use of these devices; for example, they can help workers to lift heavy objects and aid workers who need to crouch often as part of their job (e.g. automotive workers).

	Increasing advances are continuing in this area of research, and devices such as the HAL 5 exoskeleton, are already being used in workplaces, for example to help lift patients. These devices are becoming increasingly available, cheap and capable.	They could also assist elderly workers and some disabled people to participate more fully in the workplace. There may be a potential risk of injury to individuals using an exoskeleton, if it fails, or runs out of battery, or if they lose their balance and fall. Exoskeletons may also be vulnerable to software hacking. Risk of collision injury may also affect other workers nearby. Exoskeletons may also provide workers with a sense of 'invulnerability', with the result that they may be tempted to take greater risks, owing to the additional strength they have.
T2.4	**Artificial intelligence** Artificial intelligence (AI) is typified by machines making rules-based decisions autonomously from an operator and, increasingly, learning from experience. The use and complexity of AI is advancing rapidly. Advances include data mining, machine vision and computational statistics. An example is work fusion software that can automate non-routine office tasks. Current applications can be found, for example, in the food industry, call centres and warehouses. 'Digital Taylorism' (where knowledge work in a range of occupations, including professional ones, is codified and routinised to a level where a worker's input is de-skilled and the high-value part of the job role is carried out by computer algorithms) makes it possible for workers' 'bosses' to be AI machines. Estimates predict that the three occupations most likely to be automated in the future are administrative, sales and industrial processes. The work of professionals (including in law, finance, sales and a variety of public services) is also likely to become automated in the future. However, things that could delay the rise of AI at work include the difficulty of computerising creative work, social intelligence (needing a large amount of tacit knowledge of social and cultural contexts and subtleties) and tasks necessitating skills of manipulation and perception.	Sophisticated AI algorithms may allow the analysis of vast amounts of data to gain improved insight into OSH issues, such as the causes of accidents, and may provide the ability to make better OSH decisions or identify a range of problems before they occur. *AI could, for example, as one respondent to the web survey suggested, enable 'more sophisticated search facilities', which could be used for OSH purposes.* Humans and computers have complementary and different skills and capabilities that, when they work together, can make them more powerful than they are individually. IBM's Watson adopts this approach. However, open machine learning systems that could be put in place in the future may give rise to potentially unpredictable consequences that could affect OSH. Increasingly integrated, complex systems may result in undesirable and poorly understood properties in terms of OSH; this will be particularly of concern for safety-critical applications of AI. As society becomes increasingly reliant on AI systems, there is a pressing need to ensure their safety and dependability. If people work alongside AI, they may be placed under pressure to perform at the speed of the computer. AI machines may in the future even be in charge of work schedules or become workers' bosses. This could result in workers trying to achieve very high efficiency demands placed on them by a robot that does not understand that humans cannot work at maximum efficiency all the time. This could lead to psychosocial issues such as work intensification, stress and exhaustion, and to an increase in the use of performance-enhancing drugs in the workplace.

	Some also argue that the fear of AI becoming self-aware and wiping out humanity in the future could hold back advances in this field.	
T2.5	**Industry 4.0** The Internet of Things and machine-to-machine communication (M2M) are enabling an emerging trend of 'lights out' manufacturing (manufacturing without human involvement). Vast numbers of cheap sensors can take measurements, send them to the internet, store these measurements in high-speed memory banks, then understand and 'learn' in real time from the large data sets by using predictive analysis algorithms and machine learning. This information can then be sent to automated machines or robots for manufacturing. Large factories using this technology are called 'Megafabs' and they are being used in the semiconductor industry.	Generally, advances in ICT should result in safer manufacturing, as workers will be increasingly removed from hazardous processes, and factory systems can be virtually tested before use. However, the added complexity of a primarily computer-controlled plant and substituting the worker may have implications for: • The hierarchy of risk control: risks will be moved elsewhere in the manufacturing lifecycle (e.g. to maintenance activities). • The human-machine interface: increasingly, workers will interact with computer systems rather than plant processes. This may lead to a degradation of the skills of the worker over time, meaning they may find it difficult to interpret if there is something wrong with a manufacturing process or may not know how to fix a fault; this could have implications for safety. Owing to demand for skilled employees around the world, it may be difficult to recruit people with the right combination of skills required for the multi-skilled roles of the information-production engineers of the future. Therefore, it may be necessary to employ people with lower skill levels than required, which could have implications for health and safety. There may be safety risks from human and robot interaction in an automated plant. Flexible and rapid reconfiguration of factories in response to customer demand may mean that the risk profile of a factory will change regularly, which could potentially increase safety risks. This could mean that dynamic risk assessments will be needed for these reconfigurable factories. There may also be potential exposure or explosion risks from the manufacture of advanced materials, and microbiological risks from industrial biotechnology processes.

T2.6	**Additive manufacturing** Additive manufacturing (AM — also called rapid manufacturing) describes technologies (often called 3D printing) that, in an automated process, produce three-dimensional objects directly from digital models by the successive addition of materials. AM uses additive fabrication processes to construct parts that are increasingly being used directly in finished products or as components. The AM industry is growing quickly and developments are continuing; as costs continue to fall over the next ten years, use of this production method is likely to increase. This is likely to result in a large expansion of micro-enterprises as people become more familiar with this technology. The global 3D printing market is expected to reach USD 30.19 billion by 2022, growing at an annual rate of 28.5 % between 2016 and 2022. By 2020, it is predicated that Europe will exceed the USA's market share in AM. Technological developments have enabled biocompatible cells and materials to be 3D-printed into functional living tissues, in a process known as bio-printing. This has included the production and transplantation of bone, heart tissue and multilayered skin. More recently, researchers have evolved microscale 3D printing technology to include the fourth dimension of time. Known as 4D printing, in this process the hydrogel composite structures change their shape when immersed in water. This may lead to the development of further 3D-printed objects that can change form in response to a change in environment.	As AM becomes increasingly pervasive, benefits for OSH would result from removing risks to workers from moving machinery in factories and on construction sites. However, there are OSH risks from the inhalation of powders used in AM; these powders can also be a fire and explosion risk. In addition, risks could arise from the inhalation of fumes generated during the AM process. There is likely to be limited knowledge of how these AM printers are safely operated and maintained among homeowners and SMEs, who will increasingly be able to afford to own one themselves, or get access to one through the sharing economy. This could pose an OSH risk to operators. AM could result in decentralised, local manufacturing. The increasing use of such machines for manufacture in SMEs, retail and education (as rapid manufacturing is introduced into courses) could mean widely distributed hazards in small units, with new groups of workers exposed to manufacturing hazards and hazardous substances but not yet adequately trained to deal with them. This could also lead to product safety and OSH issues, where items are one-offs and OSH standards are difficult to define or enforce.
T2.7	**Autonomous vehicles** Autonomous vehicles (AVs) are increasingly being used on private land (e.g. factories and airports) and being tested on public highways worldwide. Interim features, such as self-parking and collision avoidance assistance, are already being deployed.	Connected and autonomous vehicles may create additional jobs in Europe. This would occur indirectly because of improvements to productivity and greater mobility of workers. New markets will appear in other associated sectors (e.g. digital media and telecoms). AVs and connected cars are expected to significantly reduce the number of road accidents. Fewer road accidents are likely to emerge first on motorways through platooning of heavy goods vehicles (HGVs).

	AVs could enable 'drivers' more leisure or work time, improve road capacity (particularly through platooning, where a line of driverless vehicles follows a lead vehicle, also possibly driverless, using ICT-enabled smart devices) and fuel efficiency. They may also encourage a move from rail to road. Autonomy could also be applied in other areas of transport. Shell, for example, are trialling an autonomous, crewless ship. Supporting technologies, such as vehicle-to-vehicle (V2V) communication, and increasingly connected infrastructure will enable this technology. The Institute of Electrical and Electronics Engineers says autonomous vehicles 'will account for up to 75 percent of cars on the road by the year 2040'.	However, lack of awareness/familiarity could initially lead to accidents, particularly while the majority of cars on roads remain driven by people. If autonomous vehicles are used for commuting, individuals may be less stressed and better able to concentrate at work, which could have benefits for OSH.
T2.8	**Drones** Drones are being deployed in many situations, from film and media to remote maintenance and monitoring. Their use for work purposes is expanding rapidly, and this is expected to continue and create new jobs. They are also likely to replace jobs in the agricultural sector, in surveillance of infrastructure and, potentially, in delivery services. Scientists at Leeds University in the United Kingdom, are researching the use of drones to identify and repair street lights, potholes and pipes. Drone delivery has been discussed for some time and is being trialled in some remote areas (e.g. delivering medicines to islands).	Drones have the potential to remove workers from hazardous situations, particularly those working at height, in confined spaces and in delivery of pesticides and herbicides in agriculture, and they have proven useful in monitoring the condition of infrastructure or an organisations' assets. However, there is concern that, as their numbers become much greater (owing to lower costs and improved capability), there will be a corresponding increase in their use and applications in work. There are risks from drones falling from the air, or colliding with people (a key OSH issue is humans and drones sharing the same space, especially if the spaces are enclosed), which could cause significant injury or death. Collisions with other things, such as infrastructure, aeroplanes or safety-critical work equipment, could result in catastrophic incidents.
Sub-category: Miniaturisation and Portability		
T3.1	**Growth in mobile ICT devices** Increasing computing and battery life, coinciding with miniaturisation and faster and more widespread accessibility to WiFi and 4G has created an increase in mobile, easily portable internet-connective devices. The rapid growth of mobile internet-connected devices means that there is increasingly more wireless internet access than wired.	An increasingly connected OSH community will have the ability to spread OSH messages. *For example, as one interviewee put it, 'apps are a better way of giving people OSH information than manuals'*. However, there is also the potential for loss of privacy, increased workload and difficulties in monitoring OSH remotely.

	This trend is expected to continue, enabled by technologies such as 5G and the high levels of demand generated by new working patterns. Increasing global growth in internet-connected devices means that businesses can develop new products and services, be increasingly efficient and enter new markets. This has provided millions of jobs, which is likely to continue.	Internet-connected mobile devices allow people to work anywhere and any time, enabling a 24/7 workplace, which could cause an increase in work intensity or workload, a blurring of boundaries between work and private life, and increased work-related stress. There is no real way to monitor how much or what kinds of work individuals are doing; for example, individuals could be working very long hours, or in hazardous conditions, which could affect their health. Mobile devices are less ergonomic than traditional desk-based devices, and they tend to be used in public places that are not designed as places for intensive work. Health issues can arise as a result of hunching over a smartphone for long periods; these health issues (e.g. 'text-neck') can be serious in the long term. It is believed that the adoption of a hunching posture could reduce lung capacity by up to 30 %. Wireless networks are generally less secure than wired networks; this may result in an increased cybersecurity risk for companies, which could have implications for workplace safety.
T3.2	**Wearables** Miniaturisation now means that devices, rather than being easily carried in bags or pockets, can increasingly be worn on the person or incorporated into clothing. Health and fitness applications have been the first examples of wearables in action. Navigation and payments are other leading applications. Wearable technology is expected to be able to communicate fully by about 2025. See also T2.3, 'Bionics'.	Wearables have the potential to improve and monitor the health or exposure to harmful substances of workers. This could be particularly useful for lone workers, those doing jobs that require health surveillance (e.g. asbestos workers or those exposed to noise) or those who do strenuous or safety-critical jobs, particularly if they work remotely. Privacy issues also arise from the use of this data, for example by insurance companies, in monitoring for alcohol and other drugs or in tracking location (e.g. use of electronic tags in criminal justice). Some companies are already tracking the movement and productivity of workers, who may find this intrusive and stressful.
Sub-category: Advanced Human-Machine Interfaces		
T4.1	**Augmented reality** Augmented reality (AR) provides contextual visual information alongside real-world views. Its use is now emerging in cars and work environments. AR is generally provided by displays, where information is overlaid over an individual's vision (e.g. Google Glasses).	AR has the potential to reduce mistakes during maintenance by providing real-time contextual information and checks. This will reduce accidents, as maintenance is a significant root cause of accidents both during the activity and afterwards, when equipment is back in service.

	However, a form of AR can be provided on mobile devices that display contextual information when pointed at a piece of infrastructure. AR is already being used in logistics, warehousing, automotive repair and aircraft construction.	It will also be useful in allowing workers to reference useful material while working (e.g. looking at a schematic while on a ladder and still having the use of both hands). AR on mobile devices could potentially reduce incidents in construction, for example by avoiding damage to underground services thereby removing potential exposure of workers to serious hazards such as live electrical cables. Reliability, however, is very dependent on access to up-to-date, good-quality information and a mobile signal. AR systems may cause a distraction, create a loss of situational awareness or cause disorientation.
T4.2	**Virtual reality** Virtual reality (VR) can be defined as the use of computer technology to create a simulated, immersive 3D environment that can be interacted with. Most VR systems are head-mounted displays (HMD). VR systems are becoming increasingly available and the technology is developing rapidly. There are a range of different emerging hardware and software options, for example Google Cardboard and Samsung GearVR, Oculus Rift and Sony's Project Morpheus. VR is already being used for work and training in sectors such as aviation, construction and medicine, and there are a range of applications undergoing trials in other sectors. As costs decrease, VR technology is likely to increasingly appear in workplaces.	This could lead to safer work, particularly in training, as how to do a work activity can be demonstrated without actually doing it. For example, VR has been used for training fork-lift truck drivers in Poland: a person sits in a stationary fork-lift and can operate the controls, but what they see and interact with is a virtual environment via a headset or screen. The current evidence suggests that there are two groups of users, those who like it and those who find it makes them feel nauseous. It is unclear whether technology will be able to address the motion sickness issues, or if this is a fundamental issue. There are also potential dangers from loss of situational awareness and disorientation.
T4.3	**Immersive communication** The aim of immersive communication is to use ICT technologies to create natural experiences and interactions with remote people and locations. Over the past ten years or so, a number of research groups have developed a range of technologies to capture, process, analyse, transmit and render remote people, objects and locations. Areas of research include health care, education and industrial design. Some experts believe that we are probably on the verge of moving from current teleconferencing systems to telepresence systems — a type of immersive communication that facilitates more effective remote collaboration.	This will be available soon, driven by developments in screen technology and broadband networks. Virtual reality and augmented reality will provide immersive telepresence, which could facilitate emerging online employment patterns with which various OSH risks are associated (see entries in the 'Social' category under 'Employment Patterns' above).

T4.4	**Interfacing via other human senses** Gesture control, eye tracking technology, speech recognition and instantaneous translation are becoming increasingly capable and ubiquitous.	These technologies may benefit OSH. For example, eye tracking could be used to monitor the attention of safety-critical workers (e.g. heavy goods vehicle (HGV) drivers; and speech recognition software could potentially remove the need for computer keyboards in the future, resulting in a reduction in keyboard-related MSDs in workplaces. However, there could be emerging risks, such as an increase in voice disorders. These technologies have the potential to impact on workplace safety, for example if a system fails, or if it misinterprets or fails to log a command such as a gesture.
T4.5	**Direct computer-to-brain interfaces (invasive and non-invasive)** The EU Hyper Interaction Viability Experiments (HIVE) project is probing the limits of non-invasive computer-to-brain interfaces. One of the goals is to try to produce perceptions by stimulating the brain. The project is aimed at enabling fluent brain-to-computer and computer-mediated brain-to-brain interaction. More invasive technologies that involve brain implants could also be developed.	It is not known how humans will react to the continuous high cognitive load of human-machine interfaces (HMIs). This would allow inputs directly into the brain (e.g. to allow the control of machinery, IT equipment or bionic limbs, or to treat depression). This may lead to health or safety issues as yet unknown (e.g. susceptibility to magnetic or electric fields or allergic reaction to close proximity to plastics or metals for extended periods of time, as well as blurred boundaries between professional and private life). It is unknown whether brain implants could cause brain damage or psychological harm.

Sub-category: ICT Services and Infrastructure		
T5.1	**Social media** Over the past five years or so, social media has become increasingly popular as a tool to enable individuals and businesses to communicate, network and collaborate across the world. Most likely driven by smartphone use, it is one of the fastest growth areas of the internet. Businesses are taking advantage of new opportunities to connect a global workforce and using social media for recruitment. As well as enabling one-to-one communication, social media can support group behaviour.	Social media can be a useful enabling tool for disseminating OSH messages and educating workers, and it can also improve workplace communication, which can facilitate a global workforce. By facilitating a global workforce, it may drive work intensification or make it hard to monitor the health and safety of remote workers. In addition, social media is regularly hacked, and it could provide a hacking route into organisations, which could compromise safety (e.g. in a power plant). Companies are increasingly viewing their employees' social media profiles, which could be seen as an invasion of privacy causing job insecurity and stress. Social media is used for cyberbullying, and this may affect individuals at work (e.g. causing anxiety, stress or depression).

T5.2	**Cloud computing** This allows workers across the world to work together by sharing data and information. Businesses use it to enable the use of fluid workspaces, flexible working and co-working environments. It also leads to greater levels of outsourcing and offshoring. By 2020, the amount of data going through the cloud globally is projected to be over double the amount in 2013.	Cloud computing will enable greater data sharing and connectedness across the globe, which could help to improve OSH outcomes through education, advice and knowledge sharing. It allows cheaper and quickly implemented IT systems and 'pay-as-you-go' business models, which means it enables the development of micro-enterprises (including self-employed workers/freelancers) and SMEs and allows them to compete on a global level. It may lead to increasing numbers of micro-enterprises and SMEs as the technology develops and becomes more pervasive. However, as it also enables crowd-working, and remote working, it may consequently drive work intensification or make it difficult to monitor the work conditions of workers. See S2.3, 'Crowd-working', for more information on the possible impact of this.
T5.3	**Open intellectual property movement** This includes open source software, open standards and open access publishing. Concern has been expressed that unless Europe moves to an open data model, the digital economy is unlikely to progress.	This trend will enable crowdsourcing, facilitate knowledge and skills exchange, and help with training and OSH dissemination.
T5.4	**Advanced networking, internet and WiFi protocols** Fixed broadband subscriptions have grown from 220 million in 2005 to 771 million in 2014. Multiple kinds of network technologies have been designed to make the network more flexible and agile. Software-defined networking (SDN) and OpenFlow are the greatest advances in networking in a generation, and will enable a far more secure, transparent, flexible, verifiable and functional network. Anything connected to the internet has a specific IP address. IPv4 is the current system, but increasingly there are more devices than available IPv4 addresses. IPv6 is a newer connectivity system that will globally permit multiple addresses for any device an individual has. It can enable 340 billion billion billion billion devices to connect to the internet simultaneously.	This technological advancement is likely to assist global technological diffusion in the workplace. This will allow companies to have an increasingly global workforce. It will also allow workers to compete in the global workplace more equally. It may also facilitate the spread of OSH messages, advice and guidance to a wide range of people entering the workplace. 5G technology will increase the use of hand-held devices, so it may create additional eye and hand strain (from the use of a small keyboard). Voice activation could bring benefits (e.g. reduce MSD cases caused by keyboard use), although it could also result in an increase in voice disorders. 5G will also enable and facilitate a range of other ICT technologies, which will have OSH implications, for example enabling a 24/7 workplace economy, which may increase the blurring of boundaries between work and private life, increase worker stress caused by being 'always on' or lead to increased work intensity or overwork.

	5G technology is expected to be rolled out across the EU by about 2020. It will be a transformational step-change from 4G technology, providing ultra-high broadband and full voice input capability. It will provide total mobility and enable advances such as global instantaneous communication, with no lag. It could fully replace existing office infrastructure and automation. For example, robots could be controlled by a computer in the cloud. Moreover, it is likely that current encryption technologies will be made redundant.	
T5.5	**5G mobile technology — merged with T5.4, 'Advanced networking, internet and WiFi protocols'.**	
T5.6	**Massive open online courses (MOOCs) — deleted due to duplication of S3.7, 'Access to online education'.**	
T5.7	**Cybersecurity** Statistics show that as many as 90-100 % of US companies' IT security systems are attacked. These attacks are increasingly sophisticated, with the US telecoms company Verizon claiming that 70 % of cyber-attacks are never detected. According to the US Department of Homeland Security, some of the fastest-increasing cyber-attacks in the US are against energy infrastructure and critical manufacturing. To give a European example, a German steel plant was hacked and the attackers managed to shut down the furnace. The rapidly increasing application of ICT-ETs and Big Data will provide greater scope for cyber-attacks, including criminal and 'state-sponsored' activities. There is an accelerating race between the development of cybersecurity and cyber-attackers. Open source software also provides valuable data for cyber-attacks. Many organisations may fail to keep up to date protection against this rapidly evolving threat. There is a need for more advanced IT encryption, which may struggle to keep pace with future ICT developments, such as increasingly integrated wireless networks.	Attacks on critical national infrastructure, particularly electricity supply, have the potential to harm large numbers of workers (e.g. risks from power cuts and sudden darkness, especially with moving machinery, and other safety-critical situations) and members of the public. Attacks on workplaces that contain machinery and use human-robot collaboration can create a potentially dangerous working environment. Where dangerous substances are present, harm can be done to workers, and also to members of the public if substances are released externally. These risks are potentially highest where the attack gains external control over the workplace. *As one interviewee put it, 'the trend toward BYOD [can create] issues of security and consistency'.* If confidential or sensitive information is obtained on companies or the workforce, this can affect well-being.

	Cyber-attacks can cause other kinds of damage, through identity theft, loss of data, destruction of reputation and fraud.	
T5.8	**Advanced materials** A wide range of novel materials may improve the performance of many current ICT technologies and work environments. **Nanotechnology**: at the nanoscale, ordinary substances such as carbon exhibit surprising properties — greater reactivity, unusual electrical behaviour and enormous strength. Nanotech is already with us in new medicines, coatings, composites and many more products and applications. At the nanoscale, some quantum mechanical effects can be exploited. The EU ARTIST project is exploring the limits of computerisation to bridge the world of molecules with the world of microelectronics, which could lead to completely new nanoscale information processing technology. **Graphene** in particular can be used to create super-efficient batteries; thin, flexible displays; and semi-conductor chips. **Piezoelectric** materials, which turn pressure into electricity, could be used to power mobile phones from the pressure of clothing.	Being able to power mobile devices using clothing with piezoelectric properties is likely to increase the use of wearable devices. New materials could bring yet unknown health risks, to which workers may be exposed during manufacture, use, repair or recycling. For example, some experts believe that carbon nanotubes could cause similar health risks to asbestos.

Category: ECONOMIC		
Sub-category: Globalisation		
Ec1.1	**Changes in levels of globalisation** Economic prosperity is closely linked to the extent of globalisation. Of the top 15 globalised countries, only Singapore is outside Europe. The KOF Index of Globalisation takes account of a combination of economic, social and political factors and has shown fairly steady growth, from under 40 in 1980 to 58 in 2010.	Increased globalisation allows companies to have an increasingly global workforce and potentially allows workers to compete in the global workplace more equally. However, it may also lead to more precarious employment conditions (e.g. short-term contracts, zero-hours contracts and on-call work), with increased job insecurity, reduced social rights, poorer working conditions and worse OSH as EU workers compete with workers in countries with poorer conditions.

	Economic turbulence has caused globalisation to slow since 2008, but expectations are that it will continue apace as economic conditions improve. Globalisation generates demand for ICT-enabled ways of working, including buying and selling. There have been increasing levels of internet access globally, from 220 million fixed broadband subscriptions in 2005 to 771 million in 2014. This trend is expected to continue. *However, some respondents to the web survey indicated that the trend may reverse due to 'reactions against globalisation leading to protectionism' and 'tariffs', with one asking 'Will nationalism impede the growth of globalisation?'*	Increasing competition from other countries may also lead to pressures to increase productivity in European businesses, which could lead to work intensification. This may also lead to cost pressures for businesses and a corresponding lack of investment in OSH. While a globally connected workforce may facilitate the spread of OSH messages, advice and guidance to a wider range of people entering the workplace, it is also harder to manage OSH along a global supply chain or for a globally IT-connected workforce. In addition, emerging nations' OSH attitudes or experiences may be different from the European norm. Future shifts in global economic power may have a significant effect on the European job market. This could include a reduced demand for low-skilled workers in Europe as many more low-skilled workers enter the global job market.
Ec1.2	**Offshoring** Offshoring is currently used by the majority of large companies. In a recent survey of experts from client organisations and service providers across Europe, respondents generally thought that the outsourcing market would grow in coming years, but there is uncertainty around this due to increasing costs in developing countries such as India. Nonetheless, a rise in the offshoring of knowledge-based work is expected and would be facilitated by the digital economy and crowdsourcing. The internet and developments such as cloud computing are enabling smaller companies to manage global value chains.	It is harder to manage quality and OSH along global supply chains. Increasing competition from other countries may affect job security in a global market economy, which could lead to job insecurity. It could also lead to a reduction in social rights, poorer working conditions and worse OSH as EU workers compete with workers in countries with poorer social and employment conditions. It could also increase productivity in European businesses, which could lead to work intensification. This may also lead to cost pressures for businesses and a corresponding lack of investment in OSH.
Ec1.3	**Reshoring** There is some evidence that ICT advances such as 3D printing and automation, along with concerns about quality and rising costs, are beginning to create a trend towards companies moving their manufacturing closer to home, known as 'reshoring'.	This may mean that job roles that were previously carried out overseas will return to the home country. Depending on the length of time the outsourcing has gone on, the work skills base may have reduced considerably or have gone. This may mean an increase in potential OSH risks due to work unfamiliarity and may require retraining of staff. In addition, intensive, routine or low-quality jobs may return to some countries in Europe, with a corresponding impact on OSH.

Ec1.4	**Increasingly well-educated Asian workforce** It is projected that by 2030 India and China will provide at least 60 % of workers in science, technology, engineering and mathematics.	This will result in increasing competition for European jobs, particularly medium-skilled and high-skilled jobs, which has the potential to alter the shape of the European job market. A rise in competition has the potential to drive increased productivity in the EU, which may consequently lead to work intensification. It could also lead to a reduction in social rights, poorer working conditions and worse OSH as EU workers compete with workers in countries with poorer social and employment conditions. This may also lead to cost pressures for businesses and a corresponding lack of investment in OSH.
Ec1.5	**Emerging economies** The BRIC countries (Brazil, Russia, India and China) are home to a little under half of the total population of the world and have until recently been the fastest-growing and largest emerging markets, contributing to the majority of world GDP growth. While many economists project that between 2030 and 2050 China will rise to become the largest economy in the world, economic growth in Russia and Brazil appears to have reversed. *However, as various respondents to the web survey pointed out, there are other emerging economies and 'increasing prosperity in Eastern Europe'; one respondent posed the question 'Will the EU in 30 years still [be] one of the major players in the world, or will Asia have taken over?'*	A shift in global economic power would have a significant effect on the global job market. A rise in competition from emerging economies has the potential to drive increased productivity in the EU, which may consequently lead to work intensification. It could also lead to a reduction in social rights, poorer working conditions and worse OSH as EU workers compete with workers in countries with poorer social and employment conditions. This may also lead to cost pressures for businesses and a corresponding lack of investment in OSH.

Sub-category: Macro-economic Environment		
Ec2.1	**EU growth since the financial crash of 2008** Since the global financial crash of 2008, assumptions of steady growth across Europe have been challenged. Differences in growth forecasts are perhaps the single most critical factor in scenarios for the future.	Technological change is likely to make economic growth increasingly uneven across Europe. The need to stimulate growth will drive globalisation as companies seek to do business with emerging growing markets. It will also drive innovation in order to increase productivity.

	Currently, we are seeing ongoing subdued growth in EU output, with an expectation that in the medium term growth in EU output will remain low, with a corresponding lack of demand for labour. Public debt limits are putting constraints on investment.	Low growth could potentially lead to a lack of investment in OSH.
Ec2.2	**The economic value of data** In order to create a data-enabled economy, there is a need for data to be valued economically and included on balance sheets. This will require European political support. Data sets could be traded through a regulated framework. This will require greater data standards for accuracy and calibration.	Depending whether this happens, it could either be a driver for or a barrier to a data-enabled economy. Traded data could include OSH knowledge and learning.
Ec2.3	**Insurance** If perfect data become available, there is the possibility that low-risk businesses may no longer feel it necessary to purchase insurance.	This could have implications for OSH, particularly if that leaves mostly high-risk businesses unable to afford insurance, or if insurance companies refuse insurance in some high-risk areas.
Ec2.4	**Availability of investment funding (new)** Innovation and developments in and the diffusion and use of ICT are reliant on the availability of investment funds, either from private companies or governments.	Implications for OSH could be good or bad, depending on whether the funding allows for its proper consideration.
Sub-category: Changing Industry Structure		
Ec3.1	**Micro-enterprises and small and medium-sized enterprises** Globally, there is an ongoing rise in the number of micro-enterprises and small and medium-sized enterprises (SMEs). Currently, SMEs form the majority of Europe's economy; they total 99 % of all EU businesses. SMEs have created around 85 % of new jobs in the last five years and have provided 66 % of total private sector employment in the EU.	A rise in micro-enterprises and SMEs will have an effect on the European job market profile and a corresponding effect on OSH needs and priorities for the future. Traditionally, micro-enterprises and SMEs have been a harder-to-reach community in terms of disseminating OSH information and advice; this may continue or get worse. However, ICT may also facilitate improved methods and techniques to find and engage with micro-enterprises and SMEs in terms of OSH.

	This has been partly due to micro-multinationals or the rise in digital native companies. Over the last decade, the rise of digital technologies has allowed small businesses to set up quickly and cheaply, and to build a reputation. Companies with relatively few employees now have global reach to market and distribute their products and services through the internet. By harnessing technology and using platforms, these companies have been able to quickly scale up their operations and disrupt existing markets (e.g. Uber).	
Ec3.2	**Effect of ICT on other sectors** Advances in ICT have already affected and will continue to have an impact on the amount of jobs accessible and the skills needed. Sectors already affected include the financial sector ('Blockchain' technology could potentially disrupt existing central banking by providing secure, decentralised transaction records) and the construction sector (at all stages, including design, construction and operation, computer models are being used to reduce costs).	ICT developments may change the OSH risk profile of existing jobs by introducing potential risks (e.g. advanced manufacturing and robots or AI machines), including in the service sector. IN addition, most existing jobs, even low-skilled existing ones, are likely to need increasing levels of IT competence in the future. This could cause polarisation in the European workforce and the low-skilled/educated could find it increasingly difficult to enter the job market.
Ec3.3	**Alternative distribution chains** Alternative distribution chains are emerging, such as the 'Maker Movement', where small or individual manufacturers sell directly to consumers through global websites such as Etsy and Ebay. This is being enabled by websites, open software and crowd-funding internet companies such as Kickstarter and Indigogo. Maturing technology such as AM could revolutionise supply chains. 3D-printed products from around the world are already for sale on websites such as Shapeways. In the future, AM could revolutionise manufacturing and existing distribution chains, as virtually anyone could be a manufacturer at home. A high proportion of products could be offered for sale or customised on demand.	These flexible, global approaches can disrupt existing industries and could change the profile of the manufacturing sector. An increase in home or micro-enterprise and SME manufacture may mean that it is much harder to monitor risks (e.g. hazardous working conditions and long working hours) or to spread OSH advice and guidance. Owing to the variability of products offered for sale, there may be a vastly differing OSH risk profile across this global workforce. With the emergence of AM as a potential enabler of this trend, there may be additional OSH risks from exposure to chemical particulate or fumes and fire/exposure risks; there is likely to be limited knowledge of how these AM printers are operated and maintained among homeowners and workers in micro-enterprises and SMEs, which could pose an OSH risk to operators. AM could result in decentralised, local manufacturing.

		The increasing use of such machines for manufacture in SMEs, retail and education (as rapid manufacturing is introduced into courses) could mean widely distributed hazards in small units, with new groups of workers exposed to manufacturing hazards and hazardous substances but not yet adequately trained to deal with them. This could also lead to product safety and OSH issues, where items are one-offs and OSH standards are difficult to define or enforce.
Ec3.4	**Rise of the entrepreneur** Ideal jobs may not be available to the workforce of tomorrow, so people may need to create their own jobs. This will require entrepreneurial skills and aptitudes. Digital technologies will be useful to the entrepreneur of the future as they allow low start-up costs and fast scale-up.	Low costs and fast scale-up for entrepreneurs may mean that OSH is of little concern or considered unnecessary. This group of self-employed workers may be difficult to engage with in terms of OSH and, owing to changing job roles relatively frequently, may not have the appropriate OSH knowledge for their new ventures.
Ec3.5	**Increase in e-commerce** This has been driven by the increasing pervasiveness of mobile internet devices and has resulted in an ongoing decline in retail jobs but more logistics jobs.	The rise of e-commerce has led to increasing levels of automation in the logistics sector but also a large rise in the number of warehouse workers and transport and distribution workers, who may have to demonstrate consistently high levels of productivity. Economic pressures have led companies, such as Amazon, to use digital algorithms to increase productivity and increase efficiency. It has been documented that this can increase work intensity to a level that can result in both physical injuries and mental health issues. Probable related OSH challenges are associated with repetitive tasks, manual handling, emotional labour and atypical working times, typically found in manufacturing settings, being transferred into a service sector environment.
Ec3.6	**Increasing knowledge economy** There is an ongoing trend towards a knowledge economy, which is based on trading in knowledge and information rather than physical artefacts, for example in industries such as scientific, professional and technical services.	This may improve OSH, as knowledge-based roles are likely to have a lower OSH risk than more labour-intensive jobs, such as in construction. However, there may also be new OSH challenges associated with an increasing knowledge economy, such as from crowd-work.
Ec3.7	**Rise in the service sector** Europe is experiencing an ongoing increase in the service sector.	Ongoing increases in this sector are likely to increase the OSH-related issues already associated with the service sector. This could also contribute to a polarised European workforce, with fewer medium-skilled jobs.

Ec3.8	**Sub-contracting** The growth of self-employment, crowd-work and increased globalisation tends to drive a growth in sub-contracting. Sub-contracting is highest in the United Kingdom, Spain and the Netherlands.	It is difficult to establish responsibilities for and manage OSH across lengthening supply chains.
Sub-category: New Business Models		
Ec4.1	**Sharing economy** The internet is enabling a number of new business models to emerge, notably in the area of the 'sharing economy'. For example, car-sharing companies Zipcar and BlaBlaCar are beginning to challenge the model of car ownership; and Airbnb built a network of rooms bigger than Hilton and Accor combined in just four years. The sharing economy appears to appeal to the 'millennial' generation, so can be expected to grow further and may extend more into sharing of work equipment, along the lines of a modern equivalent of agricultural cooperatives.	Large numbers of workers could become self-employed (or even undeclared workers) and it may become difficult to establish responsibility for the management of OSH as the distinction between home and private life and work disappears. Businesses may have access to more safety equipment that they may not otherwise have been able to afford. There is a need for rental companies to maintain and analyse good-quality records on, for example, the condition of equipment, component health, equipment history and operator site conditions to ensure safety standards are maintained. Big Data analytics would help to enable this. A good process for providing information for use is required to ensure that 'sharers' are competent to manage any risks and that the responsibilities for OSH are defined.
Ec4.2	**Peer-to-peer finance** Peer-to-peer finance and crowd-sourced funding are becoming more prevalent and opening up better opportunities for innovators. Blockchain, the distributed ledger system underpinning Bitcoin, offers the potential for better sharing of secure and trusted information, and the development of new applications.	This may allow businesses to have access to the newest equipment, which is likely to be better maintained and safer than older equipment.
Ec4.3	**Servitisation** Servitisation as a business model is growing as a trend. Many businesses across a range of sectors from the built environment to transport and aerospace are following this model. 'Servitisation' can be described as the process of increasing the value of products by adding services or ultimately selling services instead of products.	Servitisation increases demand for the internet of things. It should generally improve OSH in some sectors, as assets are monitored continually to assess condition and performance, which should mean that potential failures are reduced. This business model raises issue of data protection/privacy, monitoring of data, loss of control over one's data and lack of understanding of one's data use, which can in turn cause stress.

	A servitisation model is facilitated by using networks and sensors to remotely monitor a product to identify the need for maintenance or new parts. This enables a condition-based monitoring regime through the lifecycle, as opposed to typical planned preventive maintenance. At a more complex level, this can be described as a business model around a complete system, rather than an individual asset; for example, the asset is leased and data collected from the asset is used to inform the leasing contract (e.g. defined hours of operation and levels of productivity).	
Category: ENVIRONMENTAL		
Ev1	**Climate change** Despite the signing of the Paris Agreement, analysis suggests that global warming will be more substantial (at 2.7°C) and occur sooner (by 2036) than previously predicted. The most obvious consequence is an increase in extreme weather events. A second effect will be on agriculture. Potentially, increasingly tough legally imposed carbon emission targets may drive technological innovations, both in energy generation and in energy efficiency. Climate change drives technological innovation. Businesses have to implement technological solutions to enable them to cope with the impacts of climate change, such as flooding, drought, heatwaves and extended periods of freezing temperatures. Visible problems caused by climate change are likely to drive innovations to mitigate and control it through geo-engineering, which is likely to be remotely operated using ICT. At the same time, demand for global resources and raw materials is increasing. This is being exacerbated by climate change and could hinder ICT developments	The impacts of climate change, such as flooding, drought, heatwaves and extended periods of freezing temperatures can make some major hazard chemical processes difficult to safely operate or create significant major hazard potential (e.g. flooding of electrical generation plants). Flooding or heatwaves may affect ICT-based infrastructure. Extreme weather events may cause movements of people into, or northwards within, Europe (see S1.3, ‘Increasing migration into the EU’). Climate change may also lead to the emergence and spread of (zoonotic) agents and diseases in various workplaces in the EU (e.g. in workplaces in the healthcare sector or in import activities). Outdoor workers may suffer from heat exhaustion. Increased intensity of sun exposure is likely to cause a rise in skin cancers.

Ev2	**Energy** ICT currently uses a significant amount of the world's electricity, generating approximately 2 % of global carbon dioxide emissions. In the next five years, it is projected that emissions from data centres will grow the most. As IT systems are reliant on electricity, large parts of the global workplace are dependent on a regular supply of electricity. Energy shortages could occur if innovations in energy generation are not sufficient. Reductions in the availability of energy may hinder future developments of ICT. *However, several respondents to the web survey considered this unlikely, one stating that 'more use of renewables and clean energy will surely be a trend' and another pointing out that there was scope for 'more direct energy generation for devices e.g. solar'.* Along with developments in generation, such as renewables and nuclear (possibly fusion), we will see changes in energy storage and distribution. Battery technology is advancing rapidly, aiding the deployment of intermittent energy generation, such as solar and wind power. Solar power will lead to more micro-generation and innovations around a smart grid. Fracking and coal gasification offer ways of generating cheaper fuel but continue to add to carbon emissions. Their side effects remain a contentious issue. Energy efficiency improvements will become a higher priority, driving the development of the smart grid to distribute electricity intelligently to allow full network functionality.	Geopolitical events or economic and market shifts can affect the price and availability of electricity. Therefore, changes in these may have an effect on electricity supply, which will have a corresponding effect on increasingly ICT-connected workplaces; this could affect safety (e.g. if a data server for safety critical infrastructure was without power for a long period and ran out of back-up supply). Power outages also have the potential to be precursors to accidents. Energy shortages could lead organisations to generate their own energy, leading to the introduction of additional unfamiliar risks to manage. There is a general perception that new batteries are safe. However, new battery technologies will bring specific risks during manufacture, use, degradation and disposal. The potential OSH risks include: • exposure to chemicals, including nanomaterials, during manufacture, use and recycling of batteries; • electrical risks from high voltage storage; • fire and explosion risks from batteries in the workplace and vehicles.
Ev3	**Limited availability of natural resources** ICT-ET manufacture uses various natural resources. Rare earth metals, for example, are essential in many ICT-based technologies. There are increasingly lower levels worldwide and restricted exports.	There are potential health impacts from rare earth metals during the manufacturing stages of ICT devices. The limited supply of rare earth metals is also likely to lead to increased recycling of redundant ICT devices, with the associated additional health risks.

	An ongoing reduction in the availability of rare earth metals will hinder ICT developments and the advance of the digital economy, unless alternative sources (e.g. reuse from redundant electronic devices) can be found. The development of ICT-ETs could also be limited due to a lack of other natural resources, such as water.	
Ev4	**Green economy** Waste materials from the manufacture and eventual disposal of ICT equipment could become increasingly seen as a valuable commodity as a raw material for new ICT equipment or another industry, as well as being considered undesirable from a sustainability perspective. Today's linear 'take, make, and dispose' economic model relies on large quantities of cheap, easily accessible materials and energy, and may be a model that is reaching its physical limits. A green economy is restorative and regenerative by design and aims to keep products, components and materials at their highest utility and value at all times. At its simplest, it emphasises the reuse and reduction of waste products. Analysis by McKinsey estimates shifting towards a circular green economy could add USD 1 trillion to the global economy by 2025 and create 100,000 new jobs within the next five years.	Developments in the green economy could allow an increase in the availability of the raw materials that enable the continued growth of ICT technologies. It may also generate a new lifecycle for ICT-based technologies, which will in turn create new jobs in the recycling sector. This may lead to an increase in OSH risks in this area, through, for example, potential exposure to unknown chemicals and microbiological agents (e.g. precious metals can be recovered from sewage). Increasing use of X-ray-based and laser-based real-time scanning of waste materials has the potential to cause exposure of workers to ionising and/or non-ionising radiation.
Ev5	**Disease** In a more connected world, the risk of diseases arriving in Europe from other parts of the world becomes higher. Climate change may also contribute to the emergence and spread of (zoonotic) agents and diseases. The World Health Organization (WHO) has concluded that the current International Health Regulations are not sufficient to prevent threats to health such as the Ebola epidemic and the spread of the Zika virus.	Outbreaks of disease in countries outside or within Europe may affect the flow of migration into European countries. This has the potential to change the working profile of European countries, and migrants may have a different cultural expectation in relation to OSH (see S1.3, 'Increasing migration into the EU'). A large-scale outbreak of infectious disease could potentially have a wide-scale damaging impact on productivity and health systems across Europe and increase risks to healthcare workers. The use of Big Data and online collaboration/co-working could help in controlling and managing such outbreaks.

	After 70 years of successful use, the effectiveness of antibiotics is lessening as more microbes are evolving to become resistant. Over-prescribing and extensive use in livestock make the situation worse. Without effective antibiotics, much of modern surgery is at risk.	

Category: POLITICAL		
Sub-category: Political Agenda		
P1.1	**The European digital single market** This is one of the European Commission's ten priorities. A digital single market in Europe could create hundreds of thousands of jobs and bring EUR 415 billion to the EU economy each year. The digital single market strategy aims to: • help supply improved access for businesses and consumers to digital services and goods throughout Europe; • create the best conditions for digital networks to develop and for innovative services to thrive; • increase the digitalisation of European society and the European economy by promoting inter-device compatible standards; • guarantee an open internet in Europe.	All the related initiatives are designed to help enable and develop a connected digital economy across Europe. They are likely to accelerate the transformation of existing jobs by ICT development in Europe.
P1.2	**e-government** The prevalence of e-government across the EU varies substantially but is increasing everywhere. The EC e-government action plan will modernise digital public services and make the EU a better place to live, work and invest. Twenty measures will be launched by the end of 2017. The Commission will:	These initiatives are designed to help enable and develop a connected digital economy across Europe. They are likely to accelerate the transformation of existing jobs by ICT development in Europe, particularly by enabling businesses across Europe to work together more easily. With increasing data available, there should be more opportunities for effective interventions to deliver government OSH policies.

	• set up a digital single gateway enabling users to obtain all information, assistance and problem-solving services needed to operate efficiently across borders; • interconnect all business registries and insolvency registers and connect them to the e-justice portal, which will become a one-stop shop; • set up a pilot project with administrations that will apply the once-only principle for businesses across borders (this means companies will only need to provide paperwork to public authorities in one EU country, even if they operate in other EU Member States); • help EU Member States develop cross-border e-health services such as e-prescriptions and patient summaries; • accelerate the transition to e-procurement, e-signatures and implementation of the once-only principle in public procurement.	
P1.3	**Security and privacy** These are two sides of the same coin. As governments believe they need to monitor internet communications more thoroughly to prevent terrorism, the public may begin to become more concerned about its privacy. Attitudes to commercial data gathering appear to be more relaxed — until hacking is exposed.	There is a risk of cybercrime specifically aimed at damaging critical infrastructure and even compromising nuclear submarines. Workers at targeted organisations will be put at risk of harm. There will be a need to develop more sophisticated ICT security systems to counter this risk, especially as networks and devices become increasingly closely connected.
P1.4	**Investment in education and employment initiatives** It will be increasingly difficult for governments to find funds for education and employment initiatives owing to competing demands for expenditure on, for example, pension payments, social benefits and debt. Skills shortages could be a barrier to ICT innovation and adoption.	Potential cuts in investment in education programmes and employment initiatives on OSH risks could leave workers inadequately trained for their jobs. It could also lead to inequality and polarisation of the workforce.

P1.5	**Control of migration** The recent surge in migration from the Middle East and Africa has led to major re-thinking of immigration policies across Europe. The attitudes of governments to immigration affect workforce size and age structure.	Migration controls may make travel for face-to-face meetings more difficult, thereby increasing use of online working platforms. Some immigrants may face greater difficulty assimilating into the workforce owing to language and cultural differences. This could make it more difficult to communicate or manage OSH.
P1.6	**Regulation of new working patterns** In several EU countries, the status of crowd-workers will be dependent on regulatory schemes for new services. It is not certain how this will play out in the future. France, for example, is planning to vote through a measure that will give employees a 'right to disconnect' that obliges employers of over 50 people to draw up a charter of good conduct setting out when staff are not supposed to send or answer emails, which would normally be evenings and weekends.	The levels and types of EU and national political regulation of ICT will have a large impact on the development of a digital EU economy. Protection of workers using new employment patterns is essential for good OSH intervention.
P1.7	**Governance of ICT-ETs** As the use of ICT-ETs has increased, there has been a corresponding increase in demand for the regulation of their use, as well as concern about inappropriate regulation or over-regulation. For example, internet service providers can block certain material or types of electronic files. EU data protection laws also exist that prevent the passing of personal data beyond the EU unless there are sufficient safeguards in place. It is important to ensure that critical internet infrastructure is paid for. We are currently building complex ICT systems on poor foundations. There is a need for a political focus and leadership in this area.	Governance of ICT-ETs is likely to have a significant effect on the development of a digital economy in Europe. Poor online infrastructure could potentially lead to the creation of OSH risks in processes dependent on the internet of things, for example.
Sub-category: Instability		
P2.1	**Terrorism and war** Terrorist attacks in European capitals cause a reduction in travel and concerns about living/working in large cities. Generally these effects wear off after a while, but if attacks were to increase in frequency and severity then there could be a noticeable effect on patterns of behaviour.	This factor is likely to make travel for face-to-face meetings more difficult and worrying, and could therefore increase the use of online working platforms. It is also likely to put workers in major cities and in the transport sector at personal risk and under more stress.

		War can displace populations and increase migration into Europe, changing the profile of the workforce.
P2.2	**Increasing geopolitical volatility** The geopolitical landscape is continuously changing.	This has significant effects on, for example, global trade, the movement of talent around the world, and the structure of the global job market. This means that industrial sectors have to be increasingly agile. It may lead to a rise in job insecurity or work intensification (to increase productivity and thus competitiveness).
P2.3	**Blurring of borders** Given increased globalisation, the rise of digital work platforms and an increasingly networked world, borders may become blurred or even cease to exist.	It could become very difficult to regulate OSH at the social level in the future digital world of work.

Appendix K: List of participants at mini-workshop

In addition to the authors of this report (Nicola Stacey, Peter Ellwood, Sam Bradbrook, John Reynolds, Huw Williams, and David Lye), the following people, listed in alphabetical order, participated in the mini-workshop on 17 October in London.

Name	**Affiliation**
Emmanuelle Brun	European Agency for Safety and Health at Work
Jim Norton	Independent director, policy adviser and public speaker; visiting Professor of Electronic and Electrical Engineering, University of Sheffield; Chair of Serious Games International Limited; board member, Foundation for Information Policy Research (FIPR); external board member, Parliamentary Office of Science and Technology (POST), United Kingdom
Ian Pearson	Futurizon, United Kingdom
Annick Starren	European Agency for Safety and Health at Work

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The European Agency for Safety and Health at Work (EU-OSHA) contributes to making Europe a safer, healthier and more productive place to work. The Agency researches, develops, and distributes reliable, balanced, and impartial safety and health information and organises pan-European awareness raising campaigns. Set up by the European Union in 1994 and based in Bilbao, Spain, the Agency brings together representatives from the European Commission, Member State governments, employers' and workers' organisations, as well as leading experts in each of the EU Member States and beyond.

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