European Agency for Safety and Health at Work

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

European Agency for Safety and Health at Work

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This is an interim working document to inform subsequent project tasks

Executive summary

The European Agency for Safety and Health at Work (EU-OSHA) https://osha.europa.eu/ has a vision to be the European centre of excellence for occupational safety and health (OSH) information, promoting a preventive culture to support the goal of making Europe's current and future workplaces safe, healthy and productive. Following a review of priorities, EU-OSHA has commissioned a two year foresight project to provide credible and high quality information on "**New and emerging occupational safety and health risks associated with information and communication technologies and work location by 2025."**

ICT-ET affects 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. It also enables 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 (Ministry of Social Affairs and Health Finland, 2015). Even in jobs where a physical presence is required, such as manufacturing, computer control, increased automation and use of robots are changing the nature of work. Amazon's use of warehouse robots, for example, has grown from 1,400 to 30,000 in less than two years (Frey *et al*., 2016).

The importance of Information and Communications Technologies (ICT) is recognised in the European Union's ten-year jobs and growth strategy (European Commission, 2010) that was 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, which is expected to deliver high levels of employment, productivity and social cohesion by creating a European Digital Single Market (European Commission 2015; Maciejewski & Dimova 2016), which is one of the European Commission's 10 priorities.

This foresight project will be carried out in three distinct work packages: The first to identify key contextual drivers of change and trends that could contribute to creating new and emerging risks associated with ICT; the second to develop scenarios of the future and to use these to explore the future OSH challenges and opportunities; and the third to promote the project findings and use of the scenarios to address the future OSH challenges.

This first report is a working document and provides a summary of the results of the initial horizon scanning on the trends and drivers of change on ICT, digitisation, artificial intelligence (AI) and robotics. This identified ninety-two trends and drivers, which have been organised according to the Societal, Technological, Economic, Environmental and Political (STEEP) taxonomy, commonly used in foresight studies. These are listed in Table 1 below, under each of the five categories.

Table 1 – List of trends and drivers found under each of the five categories of STEEP

SOCIETAL	TECHNOLOGICAL	ECONOMIC	ENVIRONMENTAL	POLITICAL
Population changes	Technological advances in ICT	Rising globalisation	Climate change	The European digital single market
Ageing workforce	Advances in computing power and speed	Offshoring	Energy	e-Government
Increasing migration into EU	Technical challenges for ICT	Re-shoring	Limited supply of rare earth metals	Security and privacy
Generational	Need for new	Increasingly well-educated	Circular economy	Investment in education and

SOCIETAL	TECHNOLOGICAL	ECONOMIC	ENVIRONMENTAL	POLITICAL
differences	standards	workforce		employment initiatives
More women in the workforce	Internet of things	BRIC countries	Disease	Control of migration
Increasing number of workers with chronic and complex health problems	Big data	EU growth since financial crash of 2008		Regulation of new working patterns
Increased inequality and polarisation	Automation	The economic value of data		Governance of the internet
Flexible working patterns	Robotics and collaborative robots	Insurance		Terrorism and war
Virtual workplaces	Bionics	Micro and small and medium-sized enterprises		Increasing geopolitical volatility
Crowd-working	Artificial intelligence (AI)	Effect of ICT on other sectors		Blurring of borders
Fluid co-working spaces	Industry 4.0	Alternative distribution chains		
Changes to HR management	Additive manufacturing	Rise of the entrepreneur		
Shift working	Autonomous vehicles	Increase in e-commerce		
Increases in basic ICT skills	Drones	Increasing knowledge economy		
Gaps in ICT skills	Growth in mobile ICT devices	Rise in the service sector		
Increasing need for advanced reasoning skills	Wearables	Sub-contracting		
Life-long learning	Augmented reality	Sharing economy		

SOCIETAL	TECHNOLOGICAL	ECONOMIC	ENVIRONMENTAL	POLITICAL
Job mortgages	Virtual reality	Peer-to-peer finance		
Quickening pace of knowledge transfer	Immersive communication	Servitisation		
Access to online education	Interfacing via other human senses			
De-skilling	Direct brain to computer			
Attitudes to and awareness of risk	Social media			
Attitudes to online privacy	Cloud computing			
Public attitude to (acceptance of) ICT developments	Open intellectual property movement			
The future of collective action	Networking & inter-connectivity software-defined networking and Internet Protocol version 6 (IPv6)			
Rise in workplace cyberbullying	5G mobile technology			
Rise of green lobby	Massive open online courses (MOOCs)			
Smart cities	Cybersecurity			
Increased Urbanisation	Advanced materials			

A brief explanation of each of the above trends and drivers is given in Table 2 in the Results Section 3. The references are in Section 6 **Error! Reference source not found.**and the sources for the scanning data in Section 7. Fuller descriptions of each driver can be found in Table A.1 of the appendix, along with initial findings on the potential impact of each driver and trend on ICT, work location and OSH. These data will be evaluated and refined through interviews, a web-survey and a workshop that form the remainder of the first work package.

The initial conclusions, in Section 5, confirm that ICT, digitisation, AI and robotics are undergoing a rapid pace of change and becoming increasingly ubiquitous, offering access to information and content at anytime, anywhere and on any device (Maciejewski & Dimova, 2016). Technology and society increasingly co-exist, driving major changes in how people interact with one another at work and in

home life and a blurring between the two. 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’, which unlike the previous ones, is evolving at an exponential rather than a linear pace (Schwab, 2016).

Foresight on these rapid changes is vital as there will be new and emerging risks and opportunities for OSH associated with them. Initial findings suggest that risks are likely to be associated with a more diverse (age, ethnicity and skills) and dispersed workforce, cyber-security, a move to a more 24 hours, 7 days a week (24/7) digitised and virtual economy, loss of understanding, control and knowledge of automated and digital processes, poor ergonomics and exposure to, as yet unknown, chemical and biological hazards.

The current European Community (EC) strategies (EC, 2014) identify the need for a proactive approach in identifying future risks in a continuously changing world of work. This 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 impact on work location when making decisions to shape the future of OSH towards safer and healthier workplaces.

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1 Introduction

1.1 Background context

Information and communications technology (ICT), including ICT enabled technology such as robotics and artificial intelligence are likely to have major impacts on the nature and location of work over the next 10 years. Many are talking about a 'Fourth Industrial Revolution.' A connected Digital Single Market is also one of the European Commission's 10 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 decentralised community bodies. Its role is to contribute to the improvement of working life in the EU by developing, analysing and disseminating information on occupational safety and health (OSH). As a tripartite organisation, EU-OSHA works closely with governments, employers' and workers' representatives. In its role as a reference point for OSH information, EU-OSHA commissions, collects analyses and publishes new scientific research and statistics on occupational safety and health (OSH) risks. It shares good practice and communicates information in a variety of ways to reach workers and workplaces. Through its European Risk Observatory (ERO), EU-OSHA looks out for risks that are emerging due to changes in the workplace, which can 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 European Community (EC) strategies (EC, 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 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 occupational safety and health (EU-OSHA, 2013), EU-OSHA has decided to commission further foresight projects. A scoping study was undertaken and provided recommendations for possible topic(s) to be covered in a future study on new and emerging OSH risks and challenges (Cox, Fletcher & Rhisiart, 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 of new ICT in the world of work had, a year previously, also been listed by EU-OSHA as a research need (Cox, Fletcher & Rhisiart, 2014).

The importance of ICT is also recognised in the European Union'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 & Dimova, 2016) with the aim of:

- Improved 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.

- Increased digitisation of European society and 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 from changes in ICT-Ets, their use and 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 impact on work location when making decisions to shape the future of occupational safety and health (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 to 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 application 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 which are clearly relevant to OSH policy. These scenarios can then be used to stimulate discussion about the actions than can be taken today to help avoid future problems or make different versions of the future happen. The process encourages the involvement of a wide range of views in order to create different versions of the future and will be adapted to the needs of the target audience.

1.3 Project structure

This foresight project will be carried out in three distinct work packages.

The objective of the **first work package** is to identify key trends and contextual drivers of change that could contribute to creating new and emerging risks associated with ICT and changes in work location. This work package will include:

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

- Consolidation of 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 will be done through semi-structured telephone interviews and a Delphi web consultation exercise with a range of experts and key thinkers.
- Identifying the key trends and drivers, i.e. those that are actively involved in shaping the changes in the future. This will be done through the use of the impact/uncertainty matrix method during a mini-workshop with the project team and a limited number of invited experts.

The objective of the **second work package** 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 one. 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 the **third work package** 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, brings 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. 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. ICT enables people to communicate and exchange documents and information without having to be located in the same place, hence work can now be located anywhere 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 the use of ICT rather than the whole lifecycle of ICT, i.e. ICT might have an impact on manufacturing processes but the manufacture of ICT itself is not within the scope.

Embedded medical devices will only be considered in terms of their impact on OSH, either as an enabler for someone to continue to work, or as a risk created by someone in a workplace having embedded medical devices.

As well as digitisation and ICT, drivers of change on robotics (including drones) and Artificial Intelligence (AI) are within scope. The collective term ICT enabled technologies (ICT-ET) is used in this report to describe these combined sectors (a full glossary of acronyms and terms referred to in this report is provided at the end, before the appendix).

Fully defining the scope at the beginning of the project is not possible, it not being sensible to try to list everything that is within scope at this stage. Therefore, an approach will be used that allows the scope to be kept under review and developed as the project progresses.

1.5 Purpose of this report

This report introduces the project and records the results of the horizon scanning undertaken as the initial task of the first work-package. It provides, in the appendix, a description of the trends and drivers of change in ICT-ET and work location that were found through a desk-based horizon scan. It describes the methodology used to identify the trends and drivers, the results obtained and the emerging conclusions that can be drawn at this early stage of the foresight.

This report will be used to inform consultation with experts, through telephone interviews and a web-survey, to refine and consolidate the list of trends and drivers. The description of trends and drivers and the conclusions will therefore be subject to change as the foresight project progresses.

This is an internal project report and is not intended for publication. A separate summary report will be produced and provided to the experts prior to telephone interviews. The summary report will also be made available to those completing the web-survey.

2 Methodology

A project initiation meeting was held between members of the project team and representatives of EU-OSHA to consider:

- The work package plan and methodology.
- The scope of the term ‘information and communication technologies’ in the context of this project and whether EU-OSHA wished particular areas to receive emphasis.
- Participants for the interviews in the first work package.
- Reporting and project management.

A traditional literature search was conducted by HSE’s Information Consultancy Team. 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. From this 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, e.g. New Scientist, Scientific American.
- Government departments.
- University departments.
- Consulting specialists and leading thinkers on ICT-ET.

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, e.g. what to look for and where, 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 provided by the various searches were subjected to a thematic content analysis based on the STEEP (Societal, Technological, Economic, Environmental and Political) taxonomy. Selection of trends and drivers for inclusion in this report were 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-ET and on potential OSH risks and the consequences of that impact. Material not used in this report will be retained and may still be taken into account in the subsequent consolidation exercise.

3 Results

This section gives a summary of 92 trends and drivers of change, identified in this initial stage of the project, that may impact ICT–ET and the associated changes to the nature of work and work location. They have been organised according to the Societal, Technological, Economic, Environmental and Political (STEEP) taxonomy, which is commonly used in foresight studies. Under each main group, except for in the Environment group, there are also a total of sixteen sub-categories. For example 'Demographics' is a sub-category under the top-level 'Social' group and 'Autonomous Systems' is a sub-group under the top-level 'Technological' group. The majority of trends and drivers of change come under the heading of societal and technological, both with 29 each. The next largest is Economic with nineteen followed by Political with ten and Environmental with five.

There is 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 the increase in chronic health problems and an increased use of mobile devices increases chronic health problems such as MSDs;
- increased connectivity and computer power drives the use and demand for various flexible working patterns;
- changes in HR management are driven by changes to ways of working;
- the need for new skills with rapid technological change; and
- increased connectivity with need for new standards for machine to machine communication.

Each trend or driver is listed in Table 2 below with a brief explanation. The sources of information used to produce the trends and drivers are listed in Section 7 rather than cited within the table to make the table easier to use by consultees. Further information about each driver can be found in Table A.1 in the Appendix. This includes initial findings on the potential impact of each driver and trend on ICT-ET, 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.

Many trends create business opportunities, including increased productivity and growth. They may also provide OSH benefits, primarily by removing people from hazardous environments. There are also new opportunities for communicating good OSH practice. However, there are also new risks and challenges for OSH. These are primarily associated with a more diverse (age, ethnicity and skills) and dispersed workforce, cyber-attack, a move to a more 24 hours, 7 days a week (24/7) digitised and virtual economy, loss of understanding, control and knowledge of automated and digital processes, poor ergonomics and exposure to, as yet unknown, chemical and biological hazards.

Table 2: Summary of trends and drivers of change in ICT, the nature and location of work

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 where there is also a shortage of an active workforce
S1.2	**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.
S1.3	**Increasing migration into 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** - 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
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, increasing incentives at policy levels and awareness-raising initiatives
S1.7	**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.
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 in-voluntary); zero-hours' contracts (or on-demand workers); shorter-term temporary contracts; self-employment; home working; mobile working.
S2.2	**Virtual workplaces** – working online anywhere and anytime 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 work spaces 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** - 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.
Sub-category: Skills	
S3.1	**Increases in basic ICT skills**
S3.2	**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.
S3.3	**Increasing need for advanced reasoning skills** including, problem solving, judgement under uncertainty, creativity, interpersonal and emotional intelligence.
S3.4	**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.
S3.5	**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.
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** – 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 it brings with it.
S4.3	**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.
S4.4	**The future of collective action -** there is diversity in union density across EU however the general trend is a fall in TU membership. New online platforms for collective action may spring up to replace them.
S4.5	**Rise in workplace cyberbullying** – facilitated by the rise in the use of social networking.
S4.6	**Rise of 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.

Sub-category: Urban Environment	
S5.1	**Smart cities -** is 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, this trend is set to continue over the next decade.
Category: TECHNOLOGICAL	
Sub-category: Pace of change	
T1.1	**Technological advances in ICT**
T1.2	**Advances in computing power and speed**
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 of 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** – 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.
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 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 and increasingly they are able to learn from experience.
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).
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 the public highway 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 into 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, 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 are becoming increasingly capable and ubiquitous.
T4.5	**Direct brain to computer -** non-invasive computer-to-brain interfaces including trying to produce perceptions through 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	**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.
T5.5	**5G mobile technology -** provides ultra-high broadband and full voice input capability with the potential to enable global instantaneous communication, with no time-lag.

T5.6	**Massive open online courses (MOOCs) -** duplicate the best teachers, methods and course materials and are made openly available online to anyone and also apply analytics to better measure learner patterns and performance.
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	**Rising globalisation** - has shown fairly steady growth from 1980 and expectations are that it will continue apace.
Ec1.2	**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.
Ec1.3	**Re-shoring -** 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	**BRIC countries** - the BRIC countries (Brazil, Russia, India and China) are the fastest growing and largest emerging markets
Sub-category: Macro-economic environment	
Ec2.1	**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.
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 becomes available there is the possibility that low-risk businesses may no longer feel it necessary to purchase insurance.
Sub-category: Changing industry structure	
Ec3.1	**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).
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 cost and fast scale-up.
Ec3.5	**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.
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 the self-employed 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 co-operatives.
Ec4.2	**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.
Ec4.3	**Servitisation -** where the service provider owns the product that provides a service rather than the consumer of the 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 effected by energy shortages that could occur if innovations in energy generation are not sufficient.
Ev3	**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.
Ev4	**Circular economy** - waste ICT equipment could become increasingly seen as a valuable commodity as a raw material for new ICT equipment.
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 415 Billion Euros 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 can 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 due 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 the internet** - as internet use has increased there has been a corresponding rise in its regulation.
Sub-category: Instability	
P2.1	**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.
P2.2	**Increasing geopolitical volatility**
P2.3	**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.

4 Discussion

4.1 Spread and prevalence of ICT-ET

ICT is undergoing a rapid pace of change and becoming increasingly ubiquitous, offering access to information and content at anytime, anywhere and on any device (Maciejewski & 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 and a blurring between the two; and also major changes in business models and offerings.

ICT is already very prevalent in manufacturing, retail, finance and entertainment and beginning to become prevalent, although not widespread, in others, such as: healthcare, education, logistics, construction, extraction, office, legal, clerical, 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), a composite index that summarises relevant indicators on Europe's digital performance and tracks the evolution of EU Member States in digital competitiveness, Denmark, Sweden, Finland and the Netherlands have the most advanced digital economies in the EU followed by Belgium, the UK and Estonia, with Romania, Bulgaria, Greece and Italy at the bottom of the list (European Commission, 2016b). The extent of the difference is indicated by the fact that according to the EC 96% of Swedes have digital skills compared to only 50% of Romanians (Dolphin, 2015).

ICT-ETs are already enabling people to continue to work who may not otherwise have been able to e.g. 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 it. However, owing to unequal access to the necessary training and education there is a consequent unequal access, among workers, to the benefits of ICT-ET. There is also a 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 (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).

If a catastrophe occurs, which is associated with ICT-ET, then a sudden change in public attitude towards the use of ICT-ET may occur, which could potentially slow or even reverse the spread and prevalence of ICT-ET.

Employment and social security laws, education and training approaches may need to evolve to cope with a more diverse and less well defined workforce and changes to more flexible working patterns, which are expected to be brought about by an increase in the prevalence and spread of ICT-ET.

4.2 Impact of ICT-ET 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, to bring efficiency gains in terms of reduced transaction costs, dematerialised consumption (doing more with less), reduced environmental footprint, and to introduce improved business and administrative models (Maciejewski *et al.*, 2014). ICT-ET allows people to work together across national and geographical boundaries, fostering swifter globalisation (EU-OSHA, 2014).

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 & 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 single European digital market, not just in the 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 into a different industrial sector as the skills required will be similar. (Hartnett et al., 2015). It also gives those in developing/emerging economies better access to work (Leopold, Ratcheva & Zahidi, 2016).

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

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).

4.3 Impact of ICT-ET on work

ICT has had a steadily growing impact on work since personal computers first entered the workplace around 1970. The 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. Artificial Intelligence (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 when, in 1997, IBM's 'Deep Blue' became the first computer to beat a reigning world chess champion, Garry Kasparov. Now AI is being increasingly used to both augment workers, such as for medical diagnosis (IBM, 2016), or replace workers, such as financial analysts or personal assistants, in a secretarial sense (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, whilst 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-ET impacts on a great many aspects of modern life, including work. It has contributed to the virtualisation of the working environment and the development of the 24/7 and global economy, which requires the flexible organisation of work tasks, high flexibility in working hours and quasi-continuing availability for work activities. People can now communicate with each other over a variety of means – mobile phones, emails, Skype, social media. Generation Z, known as digital natives, 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 1960's fixed 'industrial robots' have been capable of performing manufacturing tasks without the need for human assistance. Over the last few years collaborative robots or 'cobots,' that work collaboratively with humans (rather than being separated from them with physical barriers), have started to have an impact on work. Fully autonomous 'robots' are also starting 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 electricity; and the third 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 are 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-ET affects 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. It also enables 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 (Ministry of Social Affairs and Health Finland, 2015). Even in jobs where a physical presence is required, such as manufacturing, computer control, increased automation and use of robots are changing the nature of work. Amazon's

use of warehouse robots, for example, has grown from 1,400 to 30,000 in less than two years (Frey *et al*., 2016).

4.4 Impact of ICT-ET on OSH

The use of ICT and ICT-ET 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-ET 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, keeping and sharing records about OSH exposures. Flexible working patterns, enabled by ICT, can contribute to well-being at work and combine work and private life. The use of ICT-ET 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-ET and the demands it 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. 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 workload and task complexity, excessive working hours, feelings of isolation (as personal relations are substituted by virtual contacts) and finding it increasingly difficult to achieve a good work-life balance due, in part, to work pressure but also driven by the ‘fear of missing out’ syndrome. As a result there is the danger that workers can suffer stress and ‘burn-out’. 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 a poorer access to OSH services. A virtual workforce could find it difficult to know that OSH information and services relevant to them exists and it could also be very difficult for OSH regulators to influence such a workforce (Ministry of Social Affairs and Health Finland, 2015).

The increasing expectation that workers will remain connected and doing computer based work whilst out of the office, including whilst travelling, requires the use of mobile devices that are less ergonomic than desk-top devices and could, therefore, cause musculo-skeletal disorders (MSDs), (Ministry of Social Affairs 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 obesity, 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), (Scientific Committee on Emerging and Newly Identified Health Risks, 2015).

A more diverse (age, ethnicity and skills) and dispersed workforce, cyber-security, a move to a more 24/7 economy, loss of knowledge of automated processes and exposure to, as yet unknown, chemical and biological hazards is likely to need new approaches to enable businesses to manage OSH; also for new approaches to regulatory intervention. These will need to reflect diversity in the workforce and new ways of working.

4.5 Trends and drivers beyond 2025

This project focuses on the period to 2025. However, we will also take into account 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 to accelerate beyond 2025. By 2030 the technology 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 is 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 it would render current data encryption techniques redundant.

5 Conclusions

Some initial conclusions can be drawn from this initial task of the first work-package of this foresight on ICT-ET. These may change as a result of the planned consultations with experts during subsequent tasks in this and the next work-package.

A total of ninety-two trends and drivers of change were found that may impact on the development of ICT-ET and associated changes to the nature of work and work location. It is expected that these will be modified, consolidated and/or added to during the planned consultation with experts. There is also considerable interaction between many of the trends and drivers.

A preliminary indication of the potential impact of the trends and drivers on ICT-ET, the nature and location of work and potential OSH implications has been made. The OSH impact of the drivers will, however, be explored in more depth in the next work-package. The scanning data suggest that the dominant OSH risks appear to be psycho-social and ergonomic. Also, 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.

Employment and social security laws, education and training approaches may need to evolve to cope with a more diverse and less well defined workforce and changes to more flexible working patterns, which are expected to be brought about by an increase in the prevalence and spread of ICT-ET.

The spread and prevalence of ICT-ET is currently varied across sectors, Europe and different social-economic groups and is expected to continue to increase across them all. However, if a catastrophe occurs, which is associated with ICT-ET, then a sudden change in public attitude towards the use of ICT-ET may occur, which could potentially slow or even reverse the spread and prevalence of ICT-ET.

There is evidence that ICT will considerably change the nature of work and may and create business opportunities, including stimulating increased productivity and growth in Europe.

Over the next decade there are likely to be significant and accelerating changes in relation to ICT-ET, the nature and location of work, with the possibility of inequality in the benefits and disadvantages experienced by different workers. It is difficult to predict these changes, so the scenarios should be a valuable tool to help inform EU decision makers, member states' governments, trade unions and employers; so that they can take appropriate account of changes in ICT-ET when making decisions to shape the future of OSH towards safer and healthier workplaces.

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8 Glossary

24/7 – 24 hours, 7 days a week – i.e. 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 multi-layered 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 to current 4G networks.
Airbnb - community marketplace founded in 2008 for people to list (principally their own homes), discover, 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 goals.
AR – Augmented Reality, where real-world views are overlaid with contextual information, usually via a display, 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-rate.
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 fasting 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.

Burn-out - a type of psychological stress, occupational burnout or job burnout is characterized by exhaustion, lack of enthusiasm and motivation, feelings of ineffectiveness, and also may have the dimension of frustration or cynicism, and as a result reduced efficacy within the workplace.
Click-and-collect – buy something online then collect it in store or 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 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 include broadband speed, affordability (mobile and fixed), skills, online communications and transactions, integration of technology into business, prevalence of digital public services.
Digital Taylorism – where tasks are standardised by use of information technology, 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 information communication technologies whereby workers schedules are set and monitored by a computer, often with an embedded continuous improvement algorithm based on average speed of workers 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 European Union 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 – Electro-Magnetic 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 - European Union'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 honey comb lattice in which each atom forms a vertex.
Generation X, Y, Z etc. – successive generations following after the 'Baby Boomers', although definitions differ, broadly Gen X were born between the early 1960s and early 1980s, Gen Y or Millennials between the early 1980s and 2000s, and variously the inception of Generation Z is put between the early 1990s and the early 2000s.
Geoengineering - the deliberate large-scale intervention in the Earth's natural systems to counteract climate change.
Green energy – energy derived from renewable resources such as tidal, wind or solar power.
HGV – Heavy Goods Vehicle.
HIVE - Hyper Interaction Viability Experiments (EU programme)
HMD – Head Mounted Displays.
HR – Human Resources.
ICT – Information Communication Technology, technology and software that enable users to access, store, transmit, and manipulate information.
ICT-ET – 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 web-site for fundraisers, helps individuals, groups and non-profits raise money online to make their ideas a reality through crowd-funding.
IoT - 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 a 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 crowdfunding platform with the mission of helping bring creative projects to life.
KOF Index – a measure of globalisation.
M2M – Machine to Machine communication, increasingly but not necessarily over the internet.
Micro enterprise – one that has fewer than 10 employees and an annual turnover or balance sheet total that does not exceed €2 million.
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 – Musculo-Skeletal Disorder, injuries or pain in the body's joints, ligament, muscles, nerves or tendons that support limbs, necks and back.
Nanotechnology – involves the manipulation of matter at a level of magnitude between 1 to 100 nanometers (1 nanometer = 1 billionth of a meter).
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** new scientific knowledge allows a long-standing issue to be identified as a risk.
NOX – generic term covering both nitric oxide and nitrogen dioxide.
Offshoring - the practice of basing some of a company's processes or services overseas, so as 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 specially 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.
Re-shoring – 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 - are 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 – ecommerce web-site selling SD 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 allows people to speak to one another over the internet and also, if they wish, see a real-time image of the person they are speaking too.
Smart-grid - An electricity supply network that uses digital communications technology to detect and react to local changes in usage.
SME – Small and Medium-sized Enterprise.
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 smart phones, tablets and other mobile devices.
Tribology - the study of friction and lubricants.
Trillion – one million million or 10^{12}.
Tripartite – containing representatives of government, workers and employers.
Tweets – 140 character messages sent to an online network of followers using Twitter.
Twitter –an online social networking service that allows users to post and read 140 character messages, 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 - is an intergovernmental organization to promote international co-operation.
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 multi-sensory and enables the participant to interact with the virtual environment.
Virtual workplaces – working online anywhere and anytime 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 specialized agency of the United Nations that is concerned with international public health.
Wi-Fi or 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: Description of trends and drivers of change

Initial findings (given in the far right column of this table) about the potential impact of each driver and trend on ICT, work location and OSH 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 source references used to generate this table can be found in Section 7.

Table A.1: Description of trends and drivers of change in ICT, nature of work and work location and potential OSH impact

Category: SOCIETAL		
Sub-category: Demographics and characteristics of the workforce		
S1.1	**Population changes** The global population is predicted to rise from 7349 million in 2015, to 8501 million by 2030. The International Labour Organization (ILO) state 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 an 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 to a diverse workforce. It may be difficult to manage the workforce due to the diversity of the team 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 share of older women in the future, with increased age diversity within the workforce. It is expected that having as many as 5 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 Human Resource (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 and 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 post aged 75 individuals begin a slow and difficult decline where both productivity and creativity are reduced. However, there is no real research on post-65

	There may be a future rise of 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 UK 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.	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 enabled technologies. Depending on the nature of work it can have either a positive or 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 an increased demand on the healthcare sector.
S1.3	**Increasing migration into EU** This is likely due to ongoing or increasingly large differences in standard of living between countries and refugees from conflict and 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 to a diverse workforce. There may be new challenges for OSH management due to the diversity of the team and the wide range of viewpoints and expectations about OSH. There will also be language barriers
S1.4	**Generational differences** Whilst 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) are beginning to enter the workplace. This cohort 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'. As well as being digitally minded they tend to be more individualistic, entrepreneurial and creative. They generally have no problem interacting with people online that they have never met. They tend to desire life-long 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	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 likely that workers using their own ICT devices at work becomes the norm – so-called Bring Your Own Device (BYOD). 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 cyber-security. Generation Z are likely to create the initial increased demand for online app facilitated shared asset platforms. Due 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, cardio-vascular, or musculoskeletal disorders. Due to the variety of jobs a worker in Generation 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

	the world and they also expect 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 want more autonomy, more control over working hours and development opportunities. They likely view their career more as a 'scramble net' rather than a ladder. **Generation X, Baby Boomers and Veterans** Due to changing retirement patterns Baby Boomers who are coming up to retirement are less likely to do so. In part, due to changes in retirement law and/or to the financial crash and loss in values of pensions so-called veterans are continuing to work, either because they still wish to or need to for financial reasons. They are more used to a hierarchical management style, less autonomy and have not grown up in a digital world and use of ICT may still be thought of a new innovation in the workplace.	exposure to health hazards. This can make prevention of work-related diseases difficult and also tracing back their cause when they occur. 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 in Generation 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 as well as Generation X are also likely be more suspicious and concerned about security of their information. How they adapt and view Generations Y and Z will be a key issue in managing OSH in the multi-generational workforce of the future. Existing management and leadership styles may be a barrier to managing OSH needs of a wide-range of competencies, both between and within occupational groups. The diversity of attitudes and behaviours associated with a multi-generational and multi-cultural 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 women make up the majority studying at university.	Generally this means that both partners work so there will be a greater need for individuals being able to balance work and home life; this will lead to demand for more flexible working arrangements. Part-time work continues to be a predominantly female domain and there has been an increase in 25% of 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, increasing incentives at policy levels 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 whilst at work. The generation of workers now entering the workforce are less active than previous generations; this means that they 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 has 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 e.g. 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 un-employed. 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 ICT developments can affect the skill distribution of employment. There is a large increase in workers at the bottom of the scale and reduction in workers at the top of the scale, with a shrinking middle class (loss of medium-skilled jobs). There is also a rise of the 'Digital Elite', with good ICT and other skills, who prosper, 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 due to	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 also may have an impact in terms of lower levels of OSH awareness.

	competing demands for expenditure from, for example pension payments, social security and interest on debts. If the costs of education are increasingly bourn 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. 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. 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). 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.	Employment and social security laws may not incorporate 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 burn-out. Globally, around 50% of individuals claim an urge to monitor work emails at home. Individuals in the UK, 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'. 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 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. Due 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 a 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.
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. This has created a positive feedback loop. As ICT makes it easier to work anywhere, then the demand to be able to do so increases, the demand for the ICT to improve, which then makes it easier to work in this way therefore creating more demand. As the number of people working this way grows so does the market which generally reduces 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, whilst 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 increasing fluid. Currently close to half of workers who work in this way are aged between 26 and 35.	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); and - Confusion between what is urgent and what is important. All the above can lead to OSH risks including increased stress, social anxiety or burnout. Also, people working in different time zones to colleagues can create 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 with an absence of supervised work schedules or working hours, which may lead to stress and burn-out. Workers will need to develop better skills for managing and organising their workload to create a good work-life balance that supports Virtual workplaces can allow employees, such as those wishing to reduce their hours as they approach retirement or 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 may not otherwise be able to. This may lead to a surplus in the market and potentially consequent job insecurity, low pay and working conditions. 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 due to the diversity of the team as there may be more conflict when there is a wide range of experience and viewpoints. Due 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 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/free lancers?) and who the employer is, as well as related open issues about 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, as people may be working at locations in different time zones to colleagues; 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 with an absence of supervised work schedules or working hours, which may lead to stress and burn-out. Workers will need to develop better skills for managing and organising their workload to create a good work-life balance that supports wellbeing. It may be difficult to manage the workforce or provide suitable OSH training due to the diversity

		and remoteness of the team. There may be more conflict when there is a wide range of experience and viewpoints. Due 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 work spaces 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 due to the 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 creates 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, who account for over a quarter of the workforce, and Generation Z, who are now or about to enter the workplace, are least likely to cope well with the increasing worker surveillance. Both HR management methods 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 wellbeing for some and a feeling of a lack of support for others.
S2.6	**Shift working** Shift work has been defined as employment in any work schedule that is not a regular daytime schedule, including regular evening or night schedules, rotating shifts, split shifts, on-call or casual shifts, 24 hour shifts, irregular schedules and other non-day schedules. Since the global recession the number of people working regular night shifts has increased to more than 3 million, in the UK 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 nightshift per month, but there are indications that the number in the EU may be falling.	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 nightshifts. Other reported health problems are: colitis, gastroduodenitis, peptic ulcers, hypertension, ischaemic heart diseases. About 20% of all workers have to stop shift work altogether after a very brief period because of serious health problems
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.
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 be need filling by 2020. A study of all of the 361 Standard Occupation Codes, covering 30 million	A lack of appropriate skills could lead to an increase in OSH risks as a consequence of poor OSH awareness and inadequate OSH training to perform the job. With the need for frequent re-training, massive open online courses (MOOCs) may enable the digitisation and modularisation of education and training. Application of analytics to better measure learner patterns should help improve the quality of MOOCs.

	people employed in the UK, 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 be increasingly important as technology becomes more pervasive and complex.	
S3.3	**Advanced reasoning skills** As automation, Artificial Intelligence (AI) and robotics increasingly penetrate the workplace advanced reasoning skills including problem solving, judgement under uncertainty, creativity, interpersonal and emotional intelligence will become increasingly important. This may lead to the requirement of higher level skills 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, 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	**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. 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** 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.	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 education, qualifications, training and experience to take from one job to another.

S3.6	**Quickening pace of knowledge transfer** Driven by instantaneous global communication, beneficial for skills transfer between workers.	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. Massive open online courses (MOOCs) also enable the digitisation and modularisation of education and training, and apply analytics to measure learner patterns better.	This could improve OSH by allowing experience and intelligence to be shared between workers and organisations. It would also facilitate greater OSH collaboration.
S3.8	**De-skilling** In some occupations jobs may become de-skilled as they become more akin to a machine operative as a consequence of e.g. 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** 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, 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 about 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 that risk and whether the inconvenience caused by the prescribed safe behaviour outweighs perceived benefits of reducing the risks.
S4.2	**Attitudes to online privacy** Issues such as online privacy and the security of data is an increasing concern.	In the workplace concerns over the collection of data on productivity and attendance can lead to

	As internet enabled devices become smaller and more pervasive (e.g. wearables), data collection is 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.	feeling of job insecurity and stress due to the real or perceived need to work faster and faster.
S4.3	**Public attitudes to ICT developments** 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 okay, unless it's considered a threat to the social model. Innovation is currently driving increasing global demand for products such as luxury electronic devices (e.g. a high-end mobile phone) or 'green energy'. This trend is expected to continue.	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 associated with an expanding workforce in these sectors who are likely to lack experience. If a workforce expands rapidly it is also difficult to provide sufficient experienced staff for adequate supervision and training.
S4.4	**The future of collective action (Trade Unions)** The level of union density across 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. Additionally, even when union membership has grown, it has not maintained pace with the increase 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 resource to campaign for improved health and safety at work. Worker involvement, for which there is good evidence that it improves OSH, is often facilitated by trade unions.

S4.5	**Workplace cyberbullying** The rise in social networking has brought about a corresponding ongoing rise in cyberbullying (this includes anonymous cyberbullying). Recent academic research has shown that cyber bullying at work is becoming as common as non-electronic forms of bullying.	Cyberbullying can cause stress, anxiety, time off work, and mental health issues.
S4.6	**Green lobby** There is an increasing awareness of and campaigning for green issues and sustainability putting pressures on organisations to respond. Most will have some form of carbon emission reduction policy in place. These often involve travel, use of natural resources such as 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** Increasing levels of ICT developments such as Big Data, the Internet of Things, high speed interconnectivity, wireless networks and social media will likely facilitate the development of smart cities. e.g. 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 those maintaining them. The increasing interconnectedness of city infrastructure and devices could mean that a failure causes a cascade of further failures affecting a wide range of infrastructure and services, which could cause implications for OSH of the workers providing the services, e.g. hospitals, schools, transport, waste collection, supply of utilities.
S5.2	**Increasing urbanisation** Individuals are increasingly moving to cities to work, 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 in 2010 to 5.2 billion by 2050.	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 (artificial intelligence 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 which 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. Hence whist there are no OSH risk specific to technological advances per se it contributes to all the associated benefits and risks specific to many of the other drivers listed elsewhere.
T1.2	**Advances in computing power and speed** Moore's Law, 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. Computers are becoming ever more powerful, increasingly reducing in cost and getting smaller. Continuing enhancements to computer speed into the future 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.	This drives increased use of ICT and underpins many of the other drivers described above and below. Hence whist there are no OSH risks specific to technological advances per se it contributes to all the associated benefits and risks 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), e.g. whilst people never felt they needed to respond quickly to a letter they feel that they do 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.	These are likely to also 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

	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 into the future 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.	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 refurbishment and recycling activities.
T1.4	**Need for new standards** There are, 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 of 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. Example applications could include: logistics, tracking deliveries; 'smart countryside' - monitoring and control of irrigation, fertiliser and weedkiller; 'smart roads' – monitoring road conditions; personal environmental monitoring –	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 toxic substances could be facilitated by the use of smart sensors incorporated into wearable devices. 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. Due to the complexity of the data workers may lack understanding of what data are collected, for what

	tracking exposure to air pollution.	purpose etc. leading to feeling 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, e.g. in a safety critical system this has potential implications for safety. The internet of things does makes organisations more vulnerable to issues around 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 is driving the generation of vast amounts of data; this growth in data production continues to rise over time. e.g. 12 terabytes of data is produced daily as Twitter 'tweets'. Currently there are approximately 1 trillion sensors producing data. Projects state that data generation will rise by 2,000 percent in 2020, compared to 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 for managing large data sets and deriving new insights into behaviours.	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. Additionally, businesses can more easily demonstrate compliance to OSH standards and regulation. Businesses are increasingly analysing their data in order to make their work processes increasingly 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, e.g. Level 2 Building Information Management (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 is also the issue of data protection/privacy, and use of data to discriminate workers. Also the complexity and lack of people

		understanding what data are collected and for what purpose. could lead to feelings of lack of control of one's data, insecurity and stress.
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.	Removes the need for people to carry out activities that can cause injury and ill health due to 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- e.g. lifting patients, thereby reducing risks 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 pressures 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, exhaustion and to an increase of use of performance-enhancing drugs in the workplace.
T2.3	**Bionics** Robotic based technologies can be used to augment human activities and strength	There are obvious benefits to OSH by using these devices e.g. helping workers to lift heavy objects,

	or overcome disabilities, for example through exoskeletons. Increasing advances are continuing in this area of research and devices such as the HAL 5 exoskeleton, are already being used in workplaces, e.g. to help lift patients. These devices are becoming increasingly available, cheap and capable.	aiding workers who need to crouch often as part of their job e.g. automotive workers. They could also assist elderly workers and some disabled people participate more fully in the workplace. There may be a potential risk of injury to individuals using the exoskeleton, if it fails, or runs out of battery, or they lose balance and fall. Exoskeletons may also be vulnerable to software hacking. Risk of collision injury may also occur to other workers nearby. Exoskeletons may also provide workers with a sense of 'invulnerability' where they may be tempted to take greater risks, due 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 that a workers input is deskilled and the high-value part of job roles 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 law) finance, sales and a variety of public services are also likely to become automated in the future. But things that could delay the rise of AI at work include: the difficulties in 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. Some also argue that the fear of AI becoming self-aware and wiping out	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 provide the ability to make better OSH decisions or identify a range of problems before they occur. Humans and computers have complementary and different skills and capabilities that, when they work together, can be 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 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 pressures 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, exhaustion and to an increase of use of performance-enhancing drugs in the workplace.

	humanity in the future could hold back advances in this field.	
T2.5	**Industry 4.0** Internet of Things and Machine to Machine communication (M2M) is enabling an emerging trend of 'lights out' manufacturing (manufacturing without human involvement). Vast numbers of cheap sensors can take measurements, send it to the internet, store these measurements in high-speed memory, then understand and 'learn' 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 like this are called 'Megafabs' and they are being used by 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 how to fix a fault; this could have implications for safety. Due to demands for skilled employees around the world, it may be difficult to recruit people with the right combination of skills required for the multi-skilled role 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 re-configuration of factories in response to customer demand may mean that the risk profile of a factory will change regularly, which could potentially raise the safety risk. 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 (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	As AM becomes increasingly pervasive benefits for OSH would result from removing risks to workers from moving machinery from factories and construction sites. However, there are OSH risks from inhalation of powders used in AM, these powders can also be a fire and explosion risk. Additionally risk could come from the inhalation of fumes generated during the AM process.

	products or as components. The AM industry is growing quickly and developments are continuing; as costs continue to fall over the next 10 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 $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 US market share in AM. Technological developments have enabled biocompatible cells and materials to be 3D printed into functional living tissues, known as bio-printing. These include: the production and transplantation of bone, heart tissue and multi-layered skin. More recently, researchers have evolved microscale 3-D printing technology to include the fourth dimension of time. Known as 4-D printing the hydrogel composite structures change their shape when immersed in water. This may lead the development of further 3-D printed objects that can change form in response to a change in environment.	There is likely to be less knowledge of how these AM printers are safely operated and maintained, by 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 the public highway worldwide. Interim features, such as self-parking and collision avoidance assistance, are already being deployed. AVs could enable 'drivers' more leisure or work time, improve road capacities (particularly platooning where a line of driverless vehicles follow 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	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). However, lack of awareness/familiarity could initially lead to accidents, particularly whilst 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.

	enable this technology. 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.’’	
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 into the future and create new jobs. They are also likely to replace jobs in the agricultural sector, surveillance of infrastructure and potentially delivery services. Scientists at Leeds University in the UK, 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 trialled in some remote areas (e.g. delivering medicines to islands).	They have the potential to remove workers from hazardous situations, particularly those working at height, in confined spaces, delivery of pesticides and herbicides in agriculture and have proven useful to monitor the condition of infrastructure or organisations’ assets. However, there is concern that as their numbers becomes much greater (due to cheaper cost 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. Or collisions with other things such as infrastructure, aeroplanes or safety critical work equipment, which 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, faster and more widespread accessibility to WiFi and 4G has created a growth of 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. This is expected to continue to grow into the future, 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 into the future.	An increasingly connected OSH community will have the ability to spread OSH messages. However, there is also the potential for loss of privacy, increased workload, and difficultly of monitoring OSH remotely. Internet-connected mobile devices allow people to work anywhere and anytime, 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 increase work-related stress. There is no real way to monitor how much or what kinds of work individuals are doing e.g. 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 more serious over the long-term. A hunching posture is believed 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. Also see bionics.	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 who do strenuous or safety critical jobs, particularly if they work remotely. Privacy issues also arise in the use of this data – e.g. by insurance companies; monitoring for alcohol and other drugs, tracking location (like criminal justice use of electronic tags). 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. Their 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). 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.	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 both during the activity and afterward when equipment is back in service. It will also be useful in allowing workers to reference useful material, whilst working e.g. looking at a schematic, whilst 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. Their reliability, however, is very dependent on access to up to date good quality information and mobile signal. However, 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	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 it has been used for training of fork-lift truck drivers in Poland; where 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

	developing rapidly. There are a range of different emerging hardware and software options: e.g. 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.	screen. The current evidence suggests that there are two groups of users, those that 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 10 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 likely 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 under Social – employment patterns
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 as eye-tracking to monitor the attention of safety critical workers e.g. heavy goods vehicle (HGV) drivers; and speech recognition software, which 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 mis-interprets or fails to log a command such as a gesture.
T4.5	**Direct brain to computer** 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 through stimulating the brain. The project is aimed at enabling fluent brain-computer and computer-	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). These may lead to health or safety issues as yet unknown (e.g. susceptibility to

	mediated brain-to-brain interaction.	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).
Sub-category: ICT services and infrastructure		
T5.1	**Social media** Over the past 5 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 1-1 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. Additionally, 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. anxiety, stress and 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-companies (including self-employed/free lancers) and SME's and allows them to compete on a global level. It may lead to increasingly numbers of micro-companies 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 driver S2.3 Crowd-working for more information on possible impact.
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 and facilitate knowledge and skills exchange and help with training and OSH dissemination.
T5.4	**Networking & inter-connectivity**	

	software-defined networking and IVP6 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 'Open Flow' 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 technology 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.
T5.5	**5G mobile technology** 5G technology will be trialled at the 2016 Rio Olympics and is expected to be rolled out across 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 facilitate the removal of work-life boundaries. It will also enable advances such as global instantaneous communication, with no lag. It can fully replace existing office infrastructure and automation. For example, robots could be controlled by a computer in the cloud. It is likely that the current encryption technologies will be made redundant.	This technology will increase the use of hand-held devices so it may create both additional eye and hand strain (from use of small keyboard). Voice activation could bring benefits, e.g. reduce MSD cases from keyboard use although it could also result in an increase in voice disorders. It will also enable and facilitate a range of other ICT technologies, which will have OSH implications e.g. enabling a 24/7 workplace economy which may increase the blurring of boundaries between work and private life, increase worker stress from being 'always on' or lead to increased work intensity or over-work.
T5.6	**Massive open online courses (MOOCs)** Massive open online courses (MOOCs) can 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.	This could lead to more effective OSH training and learning globally. However, there will be a need to ensure quality of OSH training delivered this way. Is this method of significant educational quality compared to face-to-face interaction? The potential for more effective skills training of could lead to a reduction in OSH risks through increased awareness and better management.

T5.7	**Cybersecurity** Statistics state that as much as 90-100% of US companies' IT security systems are attacked. These attacks are increasingly sophisticated with the US telecoms company Verizon claiming 70% of cyber-attacks are never detected. And 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. For example a German steel plant was hacked and the attackers managed to shut down the furnace. The rapidly increasing application of ICT-ET 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 cyber- security 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. Cyber-attacks can damage in other ways ranging from identity theft, loss of data, destruction of reputation and fraud.	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 situation) and members of the public. Attacks on workplaces that contain machinery and 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. If confidential or sensitive information is obtained on companies or the workforce this can affect wellbeing.

T5.8	**Advanced materials** A wide range of novel materials may improve the performance of many current ICT technologies and work environments. **Nanotechnology**: at nanoscale ordinary substances like 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 that 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 as asbestos.
Category: ECONOMIC		
Sub-category: Globalisation		
Ec1.1	**Rising 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 is a combination of economic, social and political factors and has shown fairly steady growth from under 40 in 1980 to 58 in 2010. 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	Increased globalisation allows companies to have an increasingly global workforce and potentially allow 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, worsening of social rights, working conditions and OSH as EU workers compete with workers in countries with poorer conditions. 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 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

	million in 2014. This trend is expected to continue.	is also harder to manage OSH along a global supply chains or a globally IT connected workforce. In addition, emerging nation's OSH attitude or experience may be different to the European norm. Future shifts in global economic power may have a big 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** Is currently used by the majority of large companies. In a recent survey of experts, from client organizations and service providers across Europe, respondents generally thought that the outsourcing market will rise in the upcoming years, but there is uncertainty around this due to increasing costs in developing countries such as India. Still a rise in the offshoring of knowledge based work is expected and facilitated by the digital economy and crowdsourcing. The internet and developments like cloud computing are enabling smaller companies to also 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 worsening of social right, working conditions and 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 corresponding lack of investment in OSH.
Ec1.3	**Re-shoring** 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 're-shoring'.	This may mean that job roles that were previously carried out overseas will return to the home country. Given 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 re-training of staff. Additionally, 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 mid-skilled and high skilled; 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 worsening of social right, working conditions and 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 corresponding lack of investment in OSH.
Ec1.5	**BRIC countries** The BRIC countries (Brazil, Russia, India and China) are the fastest growing and largest emerging markets. They comprise around a little under half of the total population of the world. Recently, BRIC have also contributed to the majority of world GDP growth. Most economists project that between 2030 and 2050 China will rise to become the largest economy in the world.	Shift in Global Economic Power will have a big effect on the global job market. A rise in competition from BRIC countries has the potential to drive increased productivity in the EU, which may consequently lead to work intensification. It could also lead to a worsening of social right, working conditions and 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 corresponding lack of investment in OSH.
Sub-category: Macro-economic environment		
Ec2.1	**EU growth since 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 of the future. 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.	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. Potentially leads 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 the need for 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 becomes 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.

Sub-category: Changing industry structure		
Ec3.1	**Micro and small and medium-sized enterprises** Globally, there is an ongoing rise in the number of Micro 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 provided 66% of the total private sector employment in the EU. 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 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.	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 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 and SMEs in terms of OSH.
Ec3.2	**Effect of ICT on other sectors** Advances in ICT have already effected and will continue to have an impact on the amount of jobs accessible and the skills needed. Sectors already affected include: Financial: 'Blockchain' technology could potentially disrupt existing central banking by providing secure, decentralised transaction records; and construction at all stages from 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. Additionally, 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 find it increasingly difficult to enter the job market.
Ec3.3	**Alternative distribution chains** Alternative distribution chains are emerging, such as 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 or Indigogo. Maturing technology such as Additive	These flexible, global approaches can disrupt existing industries and could change the profile of the manufacturing sector. An increase in home or Micro and SME manufacture may mean that it is much harder to monitor OSH e.g. hazardous working conditions and working hours or to spread OSH advice and guidance. Due to the variability of products offered for sale, there may be a vastly differing OSH risk profile across this global workforce.

	Manufacturing (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.	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 less knowledge of how these AM printers are operated and maintained, by homeowners and Micro 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 cost and fast scale-up.	Low cost and fast scale up by entrepreneurs may mean that OSH is of little concern or considered unnecessary. This group of self-employed may be difficult to engage with in terms of OSH and due 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 increases in 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, 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. Likely related OSH challenges are also associated repetitive tasks, manual handling, emotional labour and atypical working times typically found in manufacturing settings 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 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 from 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 mid-level skilled jobs.
Ec3.8	**Sub-contracting** The growth of the self-employed, crowd-work and increased globalisation tends to drive a growth in sub-contracting. Sub-contracting is highest in the UK, Spain and Netherlands.	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; AirBnB built a network of rooms bigger than Hilton and Accor combined in just 4 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 co-operatives.	Large number 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/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 enable this. A good process of providing information for use is required to ensure that 'sharers' are competent to manage any risks and 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	Increases demand for 'Internet of Things'. This should improve OSH in some sectors generally, as assets are monitored continually to assess condition and performance, which should

	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. 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 preventative 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.	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.
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 impact of climate changes such as flooding, drought, heat-waves 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 are increasing. This is being exacerbated by climate change and could hinder ICT	The impact of climate changes such as flooding, drought, heat-waves 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 plant. Flooding or heatwaves may affect ICT-based infrastructure. Extreme weather events may cause movements of people into, or northwards within Europe. – see Driver S1.3 on Increasing migration into the EU. Climate change may also lead to the emergence and spread of (zoonotic) agents and diseases in different workplaces in the EU (for example in workplaces in the health care 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.

	developments	
Ev2	**Energy** ICT currently uses a significant amount of the world's electricity, generating approximately 2% of global carbon dioxide emissions. In the next 5 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. 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 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 put pressure on 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.	Geo-political events or economic and market shifts can affect the price and availability of electricity. As such, 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; and - Fire and explosion risks from batteries in the workplace and vehicles
Ev3	**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 producer has restricted exports. 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.	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.
Ev4	**Circular economy** Todays linear 'take, make, dispose' economic model relies on large quantities of cheap, easily accessible materials and	Developments in the circular economy could allow an increase in the availability of raw materials that

	energy, and may be a model that is reaching its physical limits. A circular 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 re-use and reduction of waste products. For example, there is a limited supply of rare earth metals. Waste becomes increasingly seen as a valuable commodity as a raw material for a different industry. Analysis by McKinsey estimates shifting towards a circular economy could add $1 trillion to the global economy by 2025 and create 100,000 new jobs within the next five years.	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, e.g. potential exposure to unknown chemicals and micro-biological agents, for example precious metals can be recovered from sewage. Increasing use of X-ray 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) 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. After 70 years of successful use, the effectiveness of anti-biotics is lessening as more microbes are evolving to become resistant. Over-prescribing and extensive use in livestock make the situation worse. Without effective anti-biotics much of modern surgery is at risk.	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 driver 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 the risks to healthcare workers. The use of Big Data and online collaboration/co-working could potentially help the control and management of such outbreaks.
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 415 Billion Euros to the EU economy each year. The digital single market strategy aims to: Help supply improved access for	All these initiative are designed to help enable and develop a connected digital economy right across Europe. They are likely to accelerate the transformation of existing jobs by ICT development in Europe.

	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 economy by promoting inter-device compatible standards. Guarantee an open Internet 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: 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.	These initiatives are designed to help enable and develop a connected digital economy across Europe. They are likely to help 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.
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 begins to become more concerned about its privacy. Attitudes to commercial data gathering appear to be more relaxed –	Risks 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

	until hacking is exposed.	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 due to competing demands for expenditure from e.g. pension payments, social benefits and debt. Skills shortages could be a barrier to ICT innovation and adoption.	Potential cuts on investment in education programmes and employment initiatives on OSH risks could leave workers not adequately 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 the 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 due 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 level 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 the internet** As internet use has vastly increased, there has been a corresponding rise in regulation of the internet, e.g. Internet Service Providers can block certain material or types of electronic files. EU data protection laws also exist which prevent the passing of personal data beyond the EU unless there are sufficient guards are 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 the Internet is likely to have a large effect on the development of a digital economy in Europe. Poor online infrastructure could potentially lead to the creation of OSH risks for 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 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.	Likely to make travel for face to face meetings more difficult and worrying thereby could increase the use of online working platforms. It is also likely to put workers in major cities and 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 work, 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 to compete.
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.	Could become very difficult to regulate OSH at the social level in the future digital world of work.

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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