European Agency for Safety and Health at Work

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# Foresight on new and emerging occupational safety and health risks associated with digitalisation by 2025

## European Risk Observatory

## Report

European Agency for Safety and Health at Work

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# Executive summary

## Main objectives

A connected Digital Single Market is one of the European Commission's key priorities (EC, 2015). Digitalisation, including ICT-enabled technologies (ICT-ETs) such as robotics and artificial intelligence (AI), are likely to have major impacts on the nature and location of work over the next 10 years. Technologies are diffusing much faster than in the past and many people are talking about a 'Fourth Industrial Revolution'. It is expected to fundamentally change where we work, how we work, who will work and how people will perceive work.

The European Agency for Safety and Health at Work (EU-OSHA) therefore commissioned a foresight project on ICT and work location to develop scenarios of the future and identify potential new and emerging OSH risks. This is in line with the current European Commission strategic documents (EC, 2014; EC, 2017a), which identify the need for a proactive approach to identifying future risks to workers' safety and health in a continuously changing world of work. It also supports the implementation of a decent European Digital Single Market in line with the principles of the European Pillar of Social Rights, which constitutes the broader policy framework for action in the area of social protection and basic rights and includes the right to fair working conditions (EC, 2017b).

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 the decisions taken today. The primary target groups for this foresight project were policy-makers (including social partners) at EU and Member State level, researchers and expert audiences. The objective of the foresight project was to 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 possible new and emerging risks identified or minimise their possible negative impact in the future.

Scenarios are narratives of what alternative futures might look like, built up from an assessment of how trends and drivers of change might influence the present to create each different future. An objective of this foresight project was to use scenario development as a tool for building visions of possible futures, encouraging the inclusion of a wide range of views to assemble different versions of the future that actions taken today can help to avoid or make happen.

This foresight project was carried out in two distinct work packages, followed by a third work package to disseminate the results:

- The objective of Work Package One was to identify key trends and contextual drivers of change that could contribute to creating new and emerging OSH risks associated with digitalisation (EU-OSHA, 2017a). This was done through horizon scanning, and engagement with experts through telephone interviews, a two-stage Delphi-like web survey and workshops.
- The objective of Work Package Two was to use the key trends identified during Work Package One to develop and test four scenarios of the future world of work and new and emerging OSH risks associated with digitalisation in 2025 that would allow policy-makers to consider a range of potential future OSH implications. This was done through a series of workshops; the first workshop developed four base scenarios of the world of work in 2025, the second workshop built upon these to incorporate OSH considerations (challenges and opportunities) and the third workshop tested them.
- As part of Work Package 3 a number of dissemination workshops took place between the end of 2017 and 2019 to promote the project findings, including the use of the scenarios as a tool to address future OSH challenges associated with developments in ICT-ETs and digitalisation ([1]).

[1] The workshop summaries are made available at https://osha.europa.eu/en/tools-and-publications/seminars.

## Main findings

The emergence of new technologies, such as the IoT, AI, big data, cloud computing, collaborative robotics, AR, additive manufacturing and online platforms, (a full glossary of acronyms and terms used in this report is provided at the end, before the appendices), has a profound impact on the world of work. Although the spread and prevalence of the application of ICT-ETs are currently varied across Europe and across different sectors and socio-economic groups, ICT is becoming an integral part of nearly all sectors, rather than a sector of its own. There is evidence that over the next decade there are likely to be significant and accelerating changes in relation to ICT-ETs, which will considerably change the nature and organisation of work across Europe as well as enable new forms of work and employment status. This will have the potential to create business opportunities, including stimulating increased productivity and growth in Europe, with the possibility of growing inequality in the benefits and disadvantages experienced by workers. There could be significant losses in medium-skilled jobs and major gains in higher-skilled jobs, with concerns about a 'race to the bottom' in employment standards. There will also be major changes to the nature of work and the distribution of jobs between sectors. The workforce will be more diverse and dispersed, frequently changing jobs and working online, rather than being present in person. This will all give rise to both challenges and opportunities, including OSH ones. It is difficult to predict these changes, so scenarios of the future are a valuable tool.

The key trends and drivers identified in the project, when considered as a whole, imply that the pace of change of digital technologies and how they are exploited in the workplace are likely to be dependent on various factors:

- the level of economic growth and investments in ICT-ETs and skills on the one hand; and
- the demand for and acceptance of ICT-ETs by the public and workers, as well as how governance, management and investment-related decisions support innovations in ICT-ETs on the other hand.

These factors allowed to define four distinct scenarios of the future world of work that were fleshed out with the information generated by the experts engaged in the project.

The four scenarios produced were tested in a workshop, using a futures technique known as policy wind tunnelling. This successfully demonstrated that the four scenarios can be used to:

- help inform policy-makers so that they can take appropriate account of changes related to digitalisation, the use digital technologies and the impact on work and OSH when making decisions to shape the future to achieve safer and healthier workplaces;
- stimulate discussions that incorporate multidisciplinary perspectives about the actions that can be taken today to influence what happens in the future;
- test policies to make them more resilient to the impact of future changes to work as a result of innovation in and the application of digitalisation and ICT-ETs.

The four scenarios allowed to identify new and emerging OSH challenges relating to how ICT-ETs could change automated systems, work equipment and tools used; how work is organised and managed; business models, hierarchies, and relationships; the characteristics of the workforce; responsibilities for managing OSH; and the skills, knowledge and information required to work.

Each scenario presents different challenges and opportunities for OSH, partly influenced by the pace of change, levels of investment in OSH research, governance styles and social norms. The challenges that are likely to be present in all four scenarios, although their extent and impact may vary, are:

- the potential for automation to remove humans from hazardous environments, but also to introduce new risks, particularly influenced by the transparency of the underlying algorithms and by human-machine interfaces;
- psychosocial and organisational factors that will become increasingly more important because ICT-ETs can drive changes in the types of work available; the pace of work; how, where and when it is done; and how it is managed and overseen;
- increasing work-related stress, particularly as a result of the impact of increased worker monitoring made possible by advances in and the increasing ubiquity of wearable ICT-ETs, 24/7 availability, blurred boundaries between work and private life, and the online platform economy;

- increasing ergonomic risks due to the increase in online working and the use of mobile devices in non-office environments;
- risks associated with new human-machine interfaces, in particular related to ergonomics and cognitive load;
- cyber-security risks due to an increase in the interconnectedness of things and people;
- increasing numbers of workers treated (rightly or wrongly) as self-employed, and who could fall outside existing OSH regulation;
- changing business models and employment hierarchies due to increased online and flexible working and the introduction of algorithmic management and AI that have the potential to disrupt current mechanisms for OSH management;
- the algorithmic management of work and workers, AI, monitoring technologies, such as wearables, together with the Internet of Things and Big Data may lead to a loss of workers' control over their data, issues of data protection, ethical issues, information inequality with regard to OSH, and performance pressure on workers;
- workers lacking the necessary skills to be able to use ICT-ETs, cope with change and manage their work-life balance;
- more frequent job changes and longer working lives.

From an OSH regulatory perspective, there is therefore a potential confluence of factors whereby the use of ICT-ETs drives rapid changes in not only the technologies used at work but also the nature of work, business structures, employment status, hierarchies and relationships; the combined impact of these changes could challenge existing mechanisms for managing and regulating OSH.

Digitalisation therefore opens the door to an increase in OSH challenges, in particular of an ergonomic, organisational and psychosocial nature, that need to be better understood and managed. However, it also offers new opportunities to reduce some OSH risks or better manage them. Technology in itself is neither good nor bad; maintaining a balance between the challenges and the opportunities presented by ITC-ETs and digitalisation will depend on the proper application of the technology and on how it is managed.

Examples of OSH strategies that emerged from the discussions in the workshops held as part of this project and that could help to mitigate OSH challenges related to ICT-ETs include:

- the development of an ethical framework for digitalisation and codes of conduct;
- a strong 'prevention through design' approach that integrates a user/worker-centred design approach;
- collaboration between academics, industry, social partners and governments on research and innovation in developments ICT-ETs/digital technologies to properly take account of the human aspects;
- the involvement of workers in the implementation of any digitalisation strategies;
- advanced workplace risk assessments, using the unprecedented opportunities offered by ICT-ETs, while also considering the full range of their possible impacts in terms of OSH challenges, as identified in this foresight project;
- a regulatory framework to clarify OSH liabilities and responsibilities in relation to new systems and new ways of working;
- an adapted education system and training for workers;
- the provision of effective OSH services to digital workers.

The four scenarios have been shown to be a valuable tool for analysing future OSH challenges and opportunities. However, they are not forecasts and the future for OSH for different sectors and regions will contain elements of each of the scenarios in a combination that cannot be predicted. Using the scenarios to develop and test future strategies and policies should reduce risk and help maximise the potential opportunities.

# 1 Introduction

## 1.1 Context

Digitalisation, including information and communication technology enabled technologies (ICT-ETs) such as robotics, artificial intelligence (AI), online-platforms or the Internet of Things (IoT), is likely to have major impacts on the nature and location of work over the next 10 years. Many people are talking about a 'Fourth Industrial Revolution'.

Technologies are diffusing much faster than in the past. For example, it took commercial television 13 years to reach 50 million households and internet service providers 3 years to sign 50 million subscribers, but it took Facebook just 1 year and Twitter even less time to reach the same milestone (Bughin, Chui and Manyika, 2015). Seven out of the twelve disruptive technologies identified by the McKinsey Global Institute were ICT-ETs (Manyika et al., 2013). One of these, the IoT is growing so rapidly, 300 % in the last 4 years, that some are now referring to it as the Internet of All Things. Another is 3D printers, the price of which came down by 90 % in 4 years and the revenue from which went up four-fold in 10 years.

A connected Digital Single Market (DSM) has been made one of the European Commission's key priorities (EC, 2015). The importance of ICT was recognised in the European Union's 10-year jobs and growth strategy (EC, 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 DSM (EC, 2015; Maciejewski and Dimova, 2016) with the aims of:

- improving access for businesses and consumers to digital services and goods throughout Europe;
- creating the best conditions for digital networks to develop and for innovative services to thrive;
- increasing digitisation of European society and the European economy by promoting interoperability and standardisation;
- 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. The European Agency for Safety and Health at Work (EU-OSHA) commissioned a 2-year foresight project, 'New and emerging occupational safety and health risks associated with information and communication technologies (ICT) and work location by 2025', in March 2016 from the Health and Safety Laboratory (HSL) Foresight Centre, SAMI Consulting Limited and Futurizon Limited.

Current European Commission strategic documents (EC, 2014; EC, 2017a) identify the need for a proactive approach to identifying future risks to workers' safety and health in a continuously changing world of work. Working environments, for example, are continuously changing with the introduction of new technologies, new substances and new work processes, changes in the structure of the workforce and the labour market, and new forms of employment and work organisation. Although new work situations bring opportunities, they can also create new risks and challenges for workers and employers, which in turn demand political, administrative, technical and regulatory intervention to ensure good standards of safety and health at work are maintained.

One of EU-OSHA's key objectives is the identification and provision of credible, high-quality data on new and emerging risks in occupational safety and health (OSH) that meet the needs of policy-makers, researchers and workplace intermediaries and allow them to take timely and effective action. By helping tripartite stakeholders to address new and emerging OSH challenges together, EU-OSHA strongly supports the principles of the European Pillar of Social Rights with regard to equal opportunities and access to the labour market, fair working conditions, and social protection and inclusion. EU-OSHA seeks to identify risks and challenges to OSH that are emerging as a result of changes in the workplace, which can occur at an increasingly fast pace. Following a successful pilot large-scale foresight project on emerging green jobs and the potential implications for OSH (EU-OSHA, 2013a), EU-OSHA decided to commission further foresight projects. A scoping study was undertaken and this provided recommendations for possible topics

to be covered in a future study on new and emerging OSH risks and challenges (EU-OSHA, 2014). This scoping study identified priority key trends that might result in 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. The opportunities and risks resulting from new ICT in the world of work had, one year previously, also been highlighted by EU-OSHA as an area needing research (EU-OSHA, 2013b). More than the technology itself, ICT-related changes in the nature of work bring about not only great opportunities but also a number of safety and health risks (Degryse, 2016).

This foresight project is looking at the potential impact on work of digitalisation and rapid developments of ICT-ETs, including AI and robotics, and the resulting impact on OSH. The project aims to provide EU and Member State decision-makers, trade unions and employers with the information they need on changes in ICT, their impact on the nature and location of work, and the emerging challenges to OSH that they may bring. Therefore, it contributes to the implementation of the European Pillar of Social Rights, which constitutes the broader policy framework for action in the area of social protection and basic rights, which include the right to fair working conditions (Principle 10) (EC, 2017b).

## 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 resulting from digitalisation and changes in ICT-ETs and their use, and the impact of these changes on 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 and Member State decision-makers, 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 to achieve 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 possible new and emerging risks identified or minimise their possible negative impact in the future.

These objectives were 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' safety and health, taking account of potential new and emerging OSH risks over a 10-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 took account of the impact of major developments, in particular the European DSM, on workplaces and OSH. It required multidisciplinary input from policy-makers, OSH experts and experts from other disciplines to derive future perspectives and to explore the applications and implications of the foresight findings.

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

## 1.3 Project structure

This foresight project was carried out in two distinct work packages, followed by a third work package dedicated to disseminating the foresight results.

The objective of Work Package One was to identify key trends and contextual drivers of change that could contribute to creating new and emerging OSH risks associated with digitalisation (EU-OSHA, 2017a). Work Package One included the following three tasks:

| | |
|---|---|
| Task One | Reviewing existing information to identify trends and drivers of change to 2025 and, where possible, 5 years beyond. This was done through a combination of horizon-scanning approaches, including a traditional literature review with a focus on recent publications and grey literature. |
| Task Two | Consolidating the list of trends and drivers of change using the expertise of key people who are aware of trends and drivers of change that may not yet be described in published material. This was done through semi-structured telephone interviews and a Delphi-like web consultation exercise with a range of experts and key thinkers. |
| Task Three | Identifying the key trends and drivers, that is, those that are actively involved in shaping changes in the future. This was done through the use of the impact-uncertainty matrix method during a mini-workshop with the project team and a small number of invited experts. |

A working report presenting in detail the methodology applied for Work Package one and discussing the key trends and drivers of change in relation to digitalisation was published on EU-OSHA's website (EU-OSHA, 2017a).

The objective of Work Package Two was to develop the 2025 scenarios of the world of work and new and emerging OSH risks associated with ICT and to test them. Work Package Two included the following four tasks:

| | |
|---|---|
| Task One | Developing a set of 'base scenarios' shaped by the key trends and drivers of change from Work Package One, describing plausible visions of the world of work in 2025. |
| Task Two | Developing a set of OSH scenarios using the base scenarios developed in Task One. These were shaped in a multidisciplinary workshop, involving a representative cross-section of participants, including ICT and OSH experts as well as policy-makers, who explored the future OSH challenges and opportunities associated with ICT and workplace location in each of the base scenarios. |
| Task Three | Producing a set of visualisations to illustrate what ICT and work could look like in 2025, along with the associated OSH implications, in each scenario. |
| Task Four | Testing and refining the scenarios with regard to their use for the development of strategy options addressing the future OSH challenges identified. This was done through a workshop attended by a range of policy-makers. |

Work Package Three consisted in a number of workshops 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-ETs and digitalisation. A first dissemination and promotion workshop was delivered to EU-OSHA's focal points on 23 November 2017 in Bilbao, Spain. More dissemination workshops took place on 20 September 2018 in Ljubljana, Slovenia, on 8 November 2018 in Oslo, Norway, and on 7 February 2019 in Bucharest, Romania. The workshop summaries are made available at https://osha.europa.eu/en/tools-and-publications/seminars.

The present report is the final report on this foresight project.

## 1.4 Project scope

The scope of this foresight project is new and emerging OSH risks associated with digitalisation in 2025. Digitalisation covers a broad spectrum of technologies, including information and communication technology (ICT), robotics, AI, the IoT, wearables, big data, autonomous vehicles (including drones), Virtual Reality (VR) and Augmented Reality (AR), and additive manufacturing that are within the scope of this project. The collective term ICT-enabled technologies (ICT-ETs) is used in this report (full glossary available on section 8).

Digitalisation enables people to communicate and exchange documents and information without having to be located in the same place. Hence, much work can now be located anywhere that there is an internet connection (Mandl et al., 2015). For example:

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

This project focuses on the important issues for OSH in relation to digitalisation and associated changes in the nature, organisation and location of work within a timeframe up to 2025. It considered types of technological change at a high level rather than at the level of the detail of specific technologies, for example considering the development of computing power rather than quantum computing. The primary focus was the use of ICT-ETs rather than the whole life cycle of ICT; that is, ICT might have an impact on manufacturing processes, but the manufacture of ICT itself was not within the scope of the project.

## 1.5 Purpose of this report

This report is the final report on the foresight project. It describes the overall methodology used in this foresight project to produce 4 scenarios of the future world of work in relation to digitalisation and the new and emerging OSH risks that this may bring by 2025 (Section 2). The impact of each key trend and driver of change in each scenario is described in Section 3 and the potential impact on jobs in each scenario is described in Section 4. Section 5 contains the four scenarios produced. A more detailed discussion of potential new and emerging OSH risks associated with digitalisation identified in the foresight project is provided in Section 6. The conclusions and recommendations that can be drawn from the overall project are set out in Section 7.

For full details of all the data collected during Work Package One, including a detailed description of all the trends and drivers, see the final report on Work Package One (EU-OSHA, 2017a).

Lists of the participants who attended each workshop can be found in Appendix A and the agendas for the workshops are in Appendix B. The outputs of the first workshops (WS1-1 and WS2-1), which supported the generation of the base scenarios, were incorporated in the methodology described in Section 2. The results of the last two workshops (WS2-2 and WS2-3), which generated detailed information relevant to potential new and emerging OSH risks associated with ICT, are incorporated in Sections 5 and 6 and more detail is given in Appendices C and D. Appendix E reproduces the shortlist of key trends and drivers of change identified in Work Package One (EU-OSHA, 2017a).

# 2 Developing the scenarios

## 2.1 Identification of trends and drivers of change

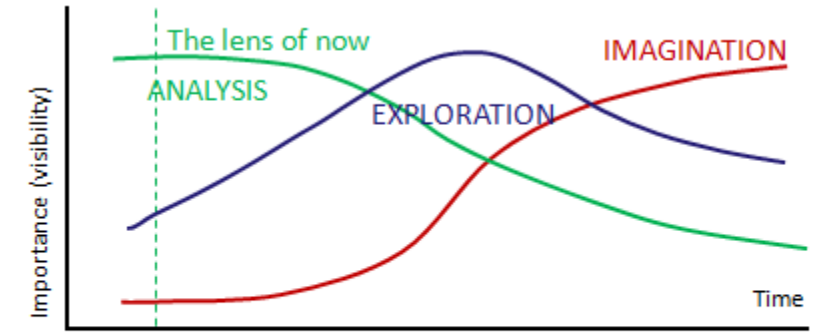
Task One of Work Package One was horizon scanning to identify a wide range of information relevant to trends and drivers of change in relation to ICT and its impact on the nature of work, including work location. This was based on a review of the following sources:

- journal papers (limited to the previous 5 years);
- publications by OSH regulators in a range of countries (current publications only);
- popular science publications (limited to the previous 5 years);
- magazines and websites of relevant professional bodies;
- technology blogs and websites;
- university and European framework research;
- documents and information published by EU-OSHA.

The project team also drew upon their knowledge from previous foresight and horizon-scanning projects with which they had been involved, and consulted ICT and OSH specialist colleagues and contacts.

The information was recorded in a 'natural agenda' consisting of five main categories: societal, technological, economic, environmental and political (STEEP). Sub-categories in each of these categories were created and used as the information found dictated, which allowed the scope to expand as required. The likely timescale for the impact to be felt was also recorded against each item as 'soon', 'more than 1 year but less than 5' or 'long'. This reflected the three-horizons model shown in Figure 1.

**Figure 1: The three-horizons model**




Once the information gathering was concluded, the information was subjected to a thematic analysis to identify and describe trends and drivers of change in each STEEP category. This resulted in a total of 92 trends and drivers: 29 societal, 29 technological, 19 economic, 5 environmental and 10 political.

Details about the method used to identify the trends and drivers of change, along with detailed descriptions of all the consolidated trends and drivers, can be found in the final report on Work Package One of this foresight project (EU-OSHA, 2017a).

## 2.2 Consolidation of trends and drivers of change

### 2.2.1 Interviews

In Task Two of Work Package One, interviews were conducted to consolidate the list of trends and drivers of change obtained from the horizon scanning described in Section 2.1 and to obtain initial views on which trends and drivers would have the greatest impact on ICT and the nature of work, including work location.

A purposive sample of 19 experts, drawn from a range of organisations, including three members of EU-OSHA's Prevention and Research Advisory Group (PRAG), were interviewed individually by telephone. The experts, who are listed in Appendix A of the final report on Work Package One of this foresight project (EU-OSHA, 2017a), were selected from countries across Europe, with expertise in a variety of fields to provide coverage of all STEEP categories. The data forthcoming as the interviews progressed were monitored to allow the expertise of subsequent interviewees to be targeted to match any gaps that became apparent.

A semi-structured approach was taken to the interviews, based on the 'Seven Questions' technique, which was developed by SAMI Consulting and is now widely used in scenario-building exercises (Ringland, 2006). The interview script, which includes the seven questions used, can be found in Appendix B of the final report on Work Package One of this foresight project (EU-OSHA, 2017a).

The questions were designed to be open, to give interviewees the freedom to develop ideas and the interviewer the freedom to explore them in more depth, where appropriate, in a relaxed, conversational manner. The comments made by interviewees were coded against the same STEEP-based 'natural agenda' used for the horizon-scanning data. The data were then analysed to see to what extent the interviews had a similar coverage of trends and drivers to the horizon scanning described in Section 2.1.

For details about the interview method, the data collected and their analysis, see the final report on Work Package One (EU-OSHA, 2017a).

### 2.2.2 Delphi-like web survey

In Task Two of Work Package One, a two-round Delphi-like web survey was conducted.

The first web survey round, hosted on the UK Health and Safety Executive (HSE) Communities internet site, was undertaken in parallel with the interviews. It was designed to complement the data from the interviews and provide quantitative data about the relative importance of the trends and drivers in each of the STEEP categories. The web survey was promoted via EU-OSHA's OSHmail, SAMI Consulting Limited's newsletter, Twitter, LinkedIn and direct emails to personal contacts of the project team. It was launched in June 2016 and remained open for a little over 4 weeks. During this period, there were 140 downloads of the consultee briefing and 114 useable responses from 22 countries. Respondents were shown a brief description of each trend or driver of change in each STEEP category and first asked whether there were any that they thought were missing or that they disagreed with. Respondents were then asked to select up to three trends and drivers (from each STEEP category) that they felt were the most important and were asked if they had any final comments. The selections made by respondents were used to rank the trends and drivers in each STEEP category.

A second, follow-up web survey was conducted to share the results and give respondents to the first a chance to comment on the overall ranking by importance of the trends and drivers. This second web survey round was hosted by the same HSE web community and was emailed directly to the 30 respondents to the first web survey who had provided contact details to indicate an interest in participating in later parts of the project. It was also promoted as a comment on the LinkedIn messages originally used to promote the first web survey. It was launched at the end of July 2016 and remained open for almost 4 weeks. During this period, 34 people opened the survey but only 11 responded to the questions. All of these 11 stated that they had responded to the previous web survey. The follow-up survey was much shorter and easier to complete than the first web survey, so complexity is unlikely to be the reason why so few did so. The timing of the survey, during the long summer vacation, is likely to have contributed to the low response rate. Another reason may have been that people did not feel qualified to comment. This possibility is supported by the fact that not all respondents commented on all the categories and by one respondent's comment to

the effect that they thought people might have not understood the concepts in the survey. While the sample was small, the responses proved very valuable in interpreting and testing the results of the first web survey. In this second round, respondents were asked the following questions:

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

For details about the web surveys, including the question sets, the data collected and their analysis, see the final report on Work Package One (EU-OSHA, 2017a).

### 2.2.3 Combining the data

The data collected through the telephone interviews and web surveys were taken together to consolidate the trends and drivers that had been identified by horizon scanning. This consolidation led to further information being added to some trends and drivers, some being modified or merged and a few new ones being added. For the consolidated list of 91 trends and drivers, with descriptions, see the final report on Work Package One (EU-OSHA, 2017a).

## 2.3 Identification of key trends and drivers of change

### 2.3.1 Initial prioritisation

In Task Three of Work Package One, the consolidated list of trends and drivers was initially prioritised by the project team. This was done with reference to the ranking of the trends and drivers and the comments on this ranking from the Delphi-like web survey, alongside data about the number of times interviewees had mentioned something that related to each trend or driver. The comments from the second web survey about the extent of agreement with the rankings produced from the first were useful for understanding differences between the rankings and the number of references made to each trend or driver by interviewees.

Consideration was given to the possibility that the data could be biased towards ‘current drivers’, or issues that had been featured heavily in the media when the interviews took place or the surveys were open. It was important that any possible bias did not result in ‘weak signals’ of emerging trends or drivers of change being filtered out, as these might be important for the ends of the scenario timelines. In assessing weaker signals, account was taken of comments made during the interviews and in the follow-up web survey. Reference was also made to the horizon-scanning data collected in Task One of Work Package One.

Account was also taken of the context of the project. For example, the European DSM was not highly scored in the web survey, but it was felt that it was important and should, therefore, form part of the discussion.

The overall spread of the prioritised drivers was considered to ensure that they covered the key issues for the project, including those highlighted in the interviews. The project team then grouped those trends and drivers that were related in terms of their potential impact.

For details about this process and the final groupings, see the final report on Work Package One (EU-OSHA, 2017a).

### 2.3.2 Final selection of key trends and drivers of change

The prioritised groups of trends and drivers were then considered during a mini-workshop, WS1-1 ([2]), to decide which of them were key. The mini-workshop was attended by the full project team (i.e. staff from HSL, SAMI and EU-OSHA) and a few independent experts to challenge the initial prioritisation and reduce the likelihood of the psychological phenomenon known as 'group-think'. A list of all those who participated in this mini-workshop can be found in Appendix A and the agenda for the workshop is in Appendix B.

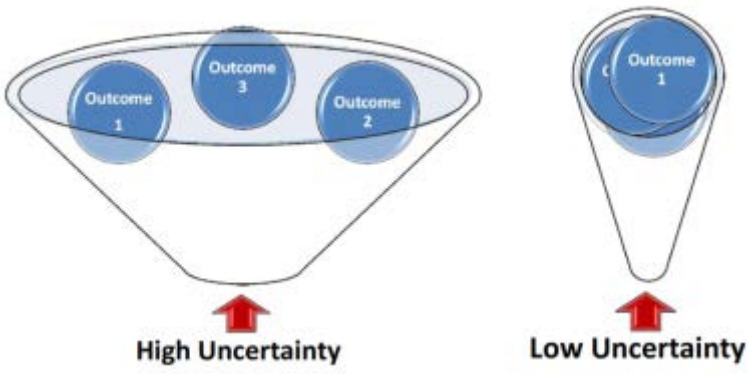
During the mini-workshop, participants first considered whether they were happy with the prioritised groups and made any changes that they agreed were necessary. This involved:

- discussing whether any other trends and drivers from the full consolidated list ([3]) (i.e. those not included in the prioritised list) were as important and adding them to the groups that they agreed, by consensus, were the most appropriate;
- moving individual trends and drivers from one group to another (including from one STEEP category to another);
- merging similar groups from different STEEP categories;
- adding any new trends and drivers of change that they considered were missing.

Participants then ranked the groups in terms of whether or not they were high impact, by comparing each group with all the others. They then selected those trends and drivers that they thought not only had a high impact but also had high levels of uncertainty associated with them. These were the 'critical uncertainties' creating the key differences between the scenarios. Trends and drivers that have a major impact but have more predictable outcomes are also important for scenario development; these, therefore, also need to be identified, so that they could be taken into account across all the scenarios.

During this process, it was important not to confuse uncertainty with probability. High uncertainty is where a trend or driver of change can result in diverse outcomes, as illustrated in Figure 2. For example, if economic growth could be accurately forecast to 2025, this would be low uncertainty, but if there could be a significantly wide range of potential rates of growth it would be high uncertainty even if each had a similar probability of happening. In addition, several groups of technology trends and drivers were identified that were high impact but for which the only uncertainty was how quickly the technology would become available and be adopted.

**Figure 2: Uncertainty levels of key trends and drivers of change**




([2]) The workshops that took place as part of this project are referred to using work package number and workshop number within the work package in chronological order. So WS1-1 is the first workshop of Work Package One, WS2-2 is the second workshop of Work Package Two, etc.

([3]) This list can be found in the final report on Work Package One of this foresight project (EU-OSHA, 2017a).

The resulting list of key trends and drivers, which can be found in Appendix E, is made up of 17 groups of trends and drivers that fell into the top right and bottom right quadrants of the impact-uncertainty matrix shown in Figure 3.

The critical uncertainties — that is, high impact, high uncertainty key trends and drivers (top right quadrant of Figure 3) — when considered as a whole, seem to indicate that the pace of change of ICT-ETs and how they are adopted in the workplace are likely to be affected by the extent to which demand for and acceptance of ICT-ETs by the public and workers, governance and investment-related decisions support innovations in ICT-ETs (particularly robotics, autonomy and AI), which drive changes in the nature of work and business structures (particularly rapid job changes and turnover). This gave four potential scenario axes (the implementation of Industry 4.0, growth, public/workers' attitudes and governance).

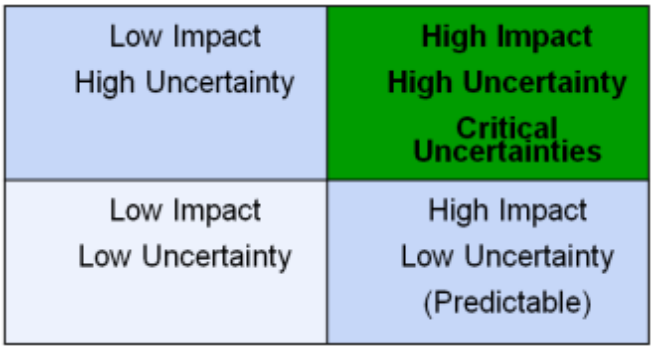
To validate these results, an initial set of four scenario sketches built along these four potential scenario axes and taking into account the key trends and drivers selected, including the high impact, low uncertainty ones (bottom right quadrant of Figure 3), was discussed at the mini-workshop (WS1-1). These scenario sketches were then used, during a meeting of members of EU-OSHA's PRAG, to further explore and test whether fully formed versions of the scenarios could:

- allow policy-makers to consider a range of potential impacts that developments in ICT could have on OSH;
- stretch current thinking by being sufficiently convincing as well as remarkable.

It was agreed by participants (a list of all those who participated can be found in Appendix A) that, once fully developed, the scenarios could meet both these criteria.

This concluded Work Package One of the foresight project (EU-OSHA, 2017a).

**Figure 3: Matrix for identifying key trends and drivers**




## 2.4 Development of the initial base scenarios

In Task One of Work Package Two, a set of base scenarios to 2025 was developed to describe alternative visions of what society, ICT developments and work could be like. This task included a mini-workshop, WS2-1, with the participation of the full project team and independent experts. A list of all those who participated in this mini-workshop can be found in Appendix A and the agenda for the workshop is in Appendix B.

This task also took account of the discussion of the scenario sketches (mentioned in Section 2.3) that took place in the Task Three, Work Package One mini-workshop (WS1-1) and in the workshop in which EU-OSHA's PRAG participated.

### *2.4.1 Development of the scenario axes*

The first task in workshop WS2-1 was to identify the scenario axes that define the spaces that contain the potential scenarios. They are based on the high impact, high uncertainty key trends and drivers (critical

uncertainties), as described in Section 2.3.2. This gave four potential axes (the implementation of Industry 4.0, growth, public/workers' attitudes and governance) to be considered by attendees, to explore if:

- plausible and internally consistent scenarios could be created;
- there was a plausible path to potential scenarios formed by the axes;
- they allowed both negative and positive aspects to emerge;
- the extent of correlation or independence between the axes was appropriate.

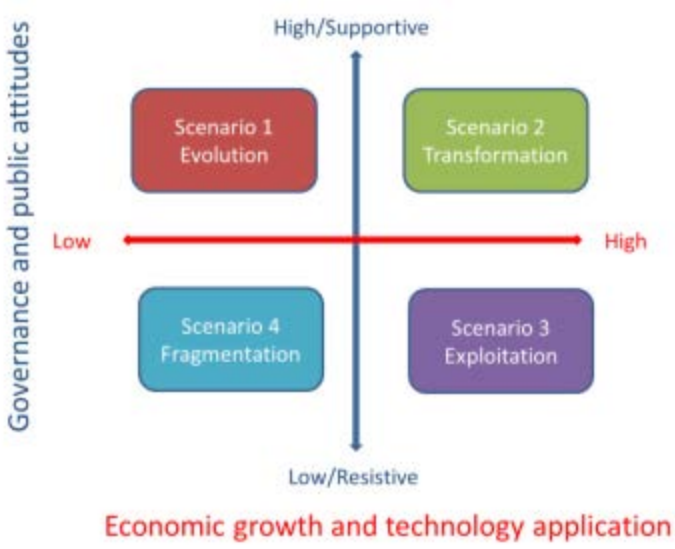
As a result, it was felt that:

- the implementation of Industry 4.0 was too narrow and should incorporate other technological innovations and the demand for and application of them;
- economic growth and investment were linked to the demand for and application of ICT;
- the extent of alignment of the leadership aspects of governance with public/workers' attitudes would create interesting differences in scenarios of the future.

This was tested by initial discussion of the possible scenarios in the four quadrants of a scenario space, illustrated in Figure 4, created using the following two axes:

1. governance and public/workers' attitudes;
2. economic growth and the application of technology.

**Figure 4: Scenario quadrants**




The next task at the mini-workshop, WS2-1, was to define the axes in more detail and outline the various end points, which should be plausible but sufficiently challenging. The results of this are outlined in the following two sections.

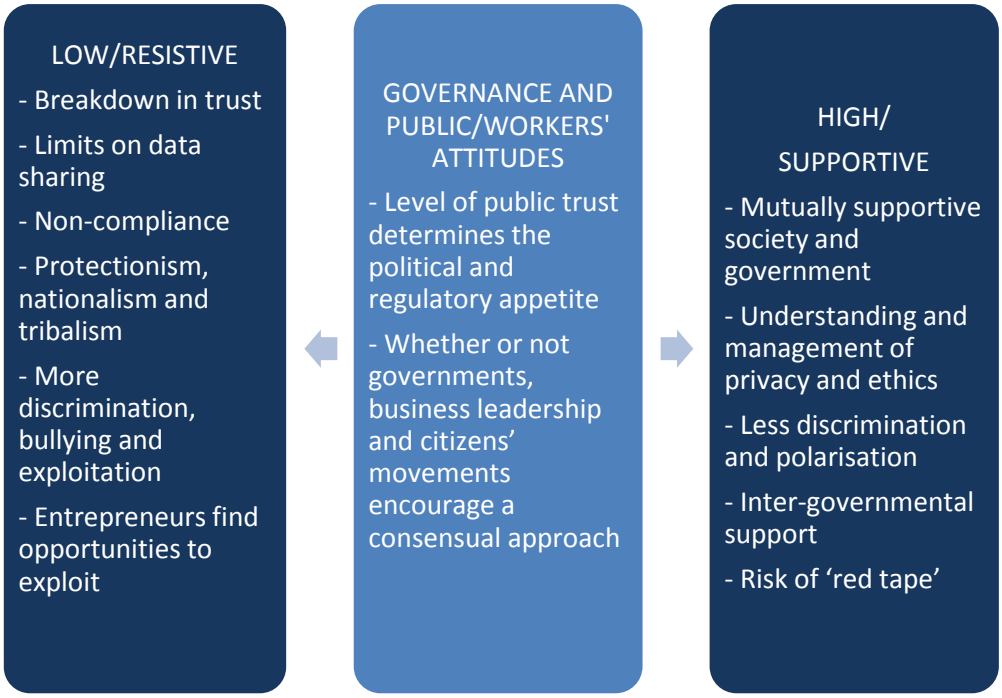
## 2.4.2 Description of vertical axis

This axis combined the key drivers on the acceptance of and demand for developments in ICT-ETs and the way in which ICT-ET innovation and implementation are governed. It was given the name 'Governance and public/workers' attitudes' and covers the following areas:

- the environment in which ICT-ETs will be exploited;
- the levels of acceptance from the public/workers;
- the levels of leadership from governments, business and workers' representatives.

These could either be supportive, with high levels of acceptance, or resistive, with low levels of acceptance, as illustrated in Figure 5.

**Figure 5: Illustration of Axis 1 — Governance and public/workers' attitudes**




The key drivers from the list in Appendix E that are part of this axis are as follows:

- **Governance**
  - the European Digital Single Market;
  - governance of ICT-ETs;
  - regulation of new working patterns;
  - changes in HR management;
  - open intellectual property (IP) movement.
- **Public/workers' attitudes**
  - the future of collective action;
  - social media;
  - security and privacy;
  - attitudes to online privacy and ethics;
  - discrimination, violence and bullying;
  - technology demand and adoption rates;
  - inequality and polarisation.

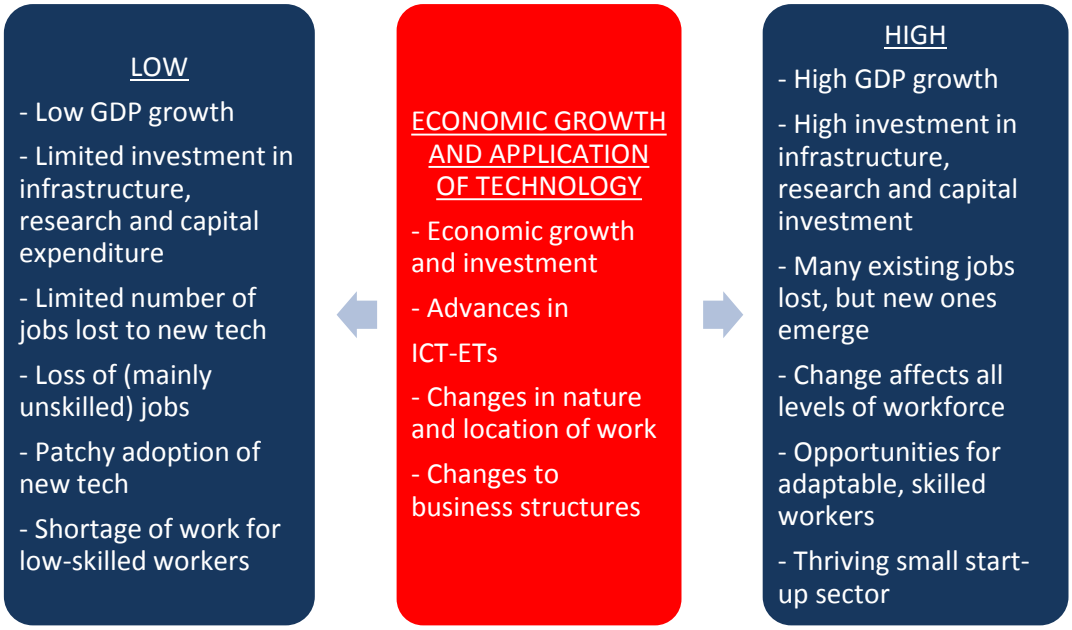
### *2.4.3 Description of horizontal axis*

This axis combined the supply-side drivers that determine investment in developments in ICT-ETs and the demand for and application of these technologies. It was given the name 'Economic growth and the application of technology' and covers the following areas:

- the level of economic growth and investments in technology and skills;
- the application of developments in ICT-ETs;
- the level of impact on the nature and locations of work, and the associated changes to business structures.

Economic growth and investment and the application of technology could be high or low, leading to the axis shown in Figure 6.

**Figure 6: Illustration of Axis 2 — Economic growth and the application of technology**




The key drivers from the list in Appendix E that are part of this axis are as follows:

- **Economic growth and investment**
  - EU growth;
  - availability of investment funding;
  - investment in education and employment initiatives;
  - changes in levels of globalisation;
  - tax planning and avoidance.
- **The demand for, adoption (i.e. pace, nature and extent) and evolution of the key technologies ([4]):**
  - robotics, autonomy and AI;
  - Internet of Things and big data;
  - cyber-security;
  - augmented and virtual reality;
  - communication networks;
  - human interfaces.
- **Impact on the nature and locations of work**
  - virtual workplaces;
  - flexible working patterns;
  - crowd-working;
  - offshoring and reshoring.

([4]) The development of the underlying technologies, such as increases in computing power, was considered to be reasonably predictable. However, the rate and nature of the application of these technologies would be highly dependent on the demand for them, the levels of investment in the necessary infrastructure to support these technologies, and the levels of research and capital expenditure.

- **Impact on skills**
  - gaps in ICT skills;
  - quickening pace of knowledge transfer;
  - more frequent and bigger shifts in skills required for work.
- **Changes to business structures**
  - micro, small and medium-sized enterprises;
  - rise of the entrepreneur;
  - sub-contracting;
  - increase in e-commerce;
  - alternative distribution chains and manufacturing;
  - sharing economy;
  - pseudo self-employment.

### 2.4.4 Selection and development of base scenarios

The final task at the mini-workshop (WS2-1) was to develop a set of base scenarios using the axes described in Sections 2.4.2 and 2.4.3 and the resulting scenario quadrants shown in Figure 4. All of these quadrants were considered and discussed to decide whether each of the scenarios would:

- allow policy-makers to consider a range of potential impacts that developments in ICT could have on OSH;
- address the critical issues that could have an impact on OSH;
- be plausible, with a plausible route from the present, and internally consistent;
- allow both negative and positive aspects to emerge;
- stretch current thinking.

It was agreed that all four scenarios met the above selection criteria.

Participants then worked in four groups to produce outlines of each base scenario. They discussed the key features in more detail and agreed what the future would be like in each scenario in 2025 and beyond. The groups then identified the key steps in a timeline from the present that would create the defined future, making modifications to the timeline as necessary. All of the consolidated trends and drivers listed in the final report on Work Package One (EU-OSHA, 2017a) were considered during the base scenario generation.

The final base scenario outlines were cross-checked against the key trends and drivers and given an initial name. Each group then described its scenario in a plenary session. During the plenary discussion, consideration was given to whether or not each base scenario still met the selection criteria. Consideration was also given to where the current dominant position in Europe was on the scenario axes and the likely paths from there to the future.

The final stage of the base scenario development was to consider whether all the base scenarios were sufficiently distinct, or whether any could be merged without losing any significant divergence. Whether or not a base scenario in addition to the above four was required was also considered. There was consensus that all four base scenarios were distinct and useful and that there was no need for any additional intermediate scenarios. The four base scenarios were then written up by the facilitator of each group. A cross-scenario impact analysis was carried out to capture and compare the features of each scenario in terms of all the key trends and drivers for each axis and the impacts of ICT-ETs in each scenario. The results of the cross-scenario impact analysis are provided in Section 3.

## 2.5 Development of OSH scenarios

In Task Two of Work Package Two, the base scenarios were developed into OSH scenarios by considering how ICT-ETs would develop in the world described in each scenario and what this could mean in terms of the general OSH environment, and new and emerging OSH risks. This was done during workshop WS2-2; the participants were 26 independent experts and policy-makers from various backgrounds and with a

range of expertise, the project team and four EU-OSHA staff members. A list of all those who participated in this workshop can found in Appendix A and the agenda for the workshop is in Appendix B.

The workshop participants were split into four groups, each working with one of the four scenarios for the whole workshop. Following a presentation of the scenarios, an initial exercise was held to familiarise participants with their respective scenarios. Each group then looked closely at how ICT-ETs could develop in its scenario and how that could affect the nature of work and changes to jobs, including new and emerging ones (see Section 4). Finally, each group looked at the OSH challenges and opportunities created by its scenario.

The ideas generated by participants during the workshop (see Appendix C) were considered and the OSH implications were added to each scenario (see Section 5); these implications are discussed in more detail in Section 6. The scenarios were also refined on the basis of comments made in the workshop.

The resulting OSH scenarios were peer-reviewed by four OSH experts who had attended workshop WS2-2 (see Table A5 in Appendix A) and the scenarios were then revised to take account of their comments as appropriate.

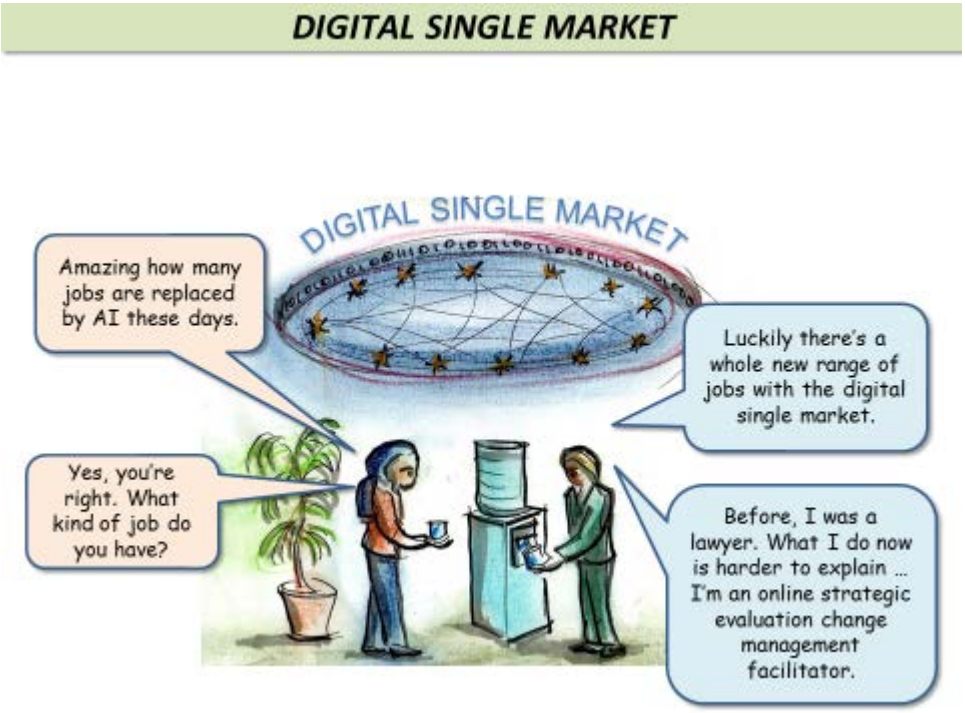
During the workshop some initial scenario visualisations were undertaken, to help facilitate the discussions. These helped to develop ideas for the next task, outlined in Section 2.6

## 2.6 Development of scenario visualisations

In Task Three of Work Package Two, visualisations were produced to highlight key aspects of the scenarios and the OSH implications. They are not intended to be representations of actual events that could occur in the future. They are intended to promote broader thinking about and discussion of the OSH implications of the changing nature of work. They were designed to prompt discussion during the workshops and make readers of this report think around the issues raised.

An initial set of four visualisations for each scenario was produced and tested during a workshop, WS2-3, in which the OSH scenarios were also tested (as described in Section 2.7). An example of one of these is shown in Figure 6.

**Figure 7: Example of a scenario visualisation**



The scenario visualisations were seen as helpful in bringing the scenarios to life and prompting discussion. Following the workshop, the scenario visualisations were reviewed, taking into account comments on both the visualisations and the scenarios.

Following workshop WS2-3, additional OSH visualisations were produced based on the results of the discussions on OSH in the workshop.

The final versions of the visualisations are included in Sections 5 and 6.

## 2.7 Testing and consolidation of scenarios

In Task Four of Work Package Two, the OSH scenarios were tested in workshop WS2-3, with policy-makers and experts from various disciplines. A list of all those who participated in this workshop can be found in Appendix A and the agenda for the workshop is in Appendix B.

The workshop participants were split into four groups, each of which worked with one of the four scenarios for the whole workshop. Following a presentation of potential developments in technology, the scenarios and the potential OSH implications, an initial exercise was held to familiarise participants with their respective scenarios. Each group then discussed the OSH challenges and opportunities in its scenario and considered potential strategy and policy responses to the new and emerging OSH challenges. These responses were then discussed and reviewed to test their robustness in the other three scenarios. This process (often termed wind tunnelling) helps to explore ways to optimise future success, identify future risks to meeting objectives, challenge any set 'official views' of the future, and create an environment for an open debate on policy and delivery options. The results of workshop WS2-3 can be found in Appendix D.

The final version of the consolidated scenarios can be found in Section 5.

# 3 Potential impacts of ICT-ETs on jobs in the four scenarios

This section draws on the discussion in workshop WS2-2 in relation to the development of the OSH scenarios and the scanning database from Work Package One. It looks at the potential impacts of ICT-ETs on jobs across the four scenarios, taking into account the mix of high-, medium- and low-skilled jobs in each sector of the European economy.

Technology is having a significant impact on jobs, skills, work organisation and ways of engaging with workers, for example in the case of online platforms, managing workers through algorithms or interfacing with AI machines and cobots. These trends are likely to accelerate and by 2025 a significant proportion of people entering the workforce will be working in jobs that do not currently exist.

There are a wide range of estimates of the number of jobs that are likely to be at high risk of automation over the next 10-15 years. Depending on the source, for both the USA and the EU the estimates vary between as high as half of all jobs and as low as about one tenth (Bowles, 2014; Brynjolfsson and McAfee, 2014; Frey and Osborne, 2013; PwC, 2017). There will also be different potential impacts across the EU, depending on the skills profile of regions' economies, as there is likely to be significantly less demand for medium-skilled workers and more demand for workers with high-level skills that complement the new technologies.

One reason for the wide range of forecasts on the impacts on jobs is that the application of ICT-ETs will be influenced by the key drivers and trends (listed in Appendix E) and the outcomes that they could produce across the four scenarios. They will affect both the nature and the scale of impacts on jobs. The overall impacts of ICT-ETs across the four scenarios are summarised in Table 4.

**Table 1: Cross-scenario analysis of impacts of ICT-ETs**

| Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|
| The impact of ICT-ETs on jobs has been evenly spread across the economy, with approaching half of jobs having significantly changed since 2017. However, only about one tenth of jobs have been completely replaced by automation. This has been restricted by limited investment in R&D and capital investment, coupled with recognition of the economic and societal value of work. | The impact of ICT-ETs on jobs has been evenly spread across the economy, and most jobs have changed significantly since 2017. This has been supported by high levels of investment from governments and business. About half of jobs have either been replaced by automation or have fundamentally changed. Strong growth and new opportunities in a changing economy have created significant numbers of new jobs. | The impact of ICT-ETs on jobs has varied across the economy, driven by the desire to maximise profits. Approaching half of jobs have been fully automated, mainly routine and repetitive jobs to save costs. High unemployment and competition for jobs have reduced the financial benefits of automating more complex jobs. Relatively few new jobs have been created, mainly higher-skilled jobs related to new technologies. | The impact of ICT-ETs has varied widely but has on average been low across most of the economy owing to low economic growth and limited investment in R&D and capital investment. In total, about one fifth of jobs, mainly lower-skilled jobs, have been fully automated. There have been areas of high levels of automation of mainly low-skilled repetitive tasks where this has saved costs. In addition, in some cases, workers' opposition to limited automation has caused disruption and strengthened the case for full automation. |

The different patterns of application of ICT-ETs will result in different impacts across sectors of the economy by 2025. There will be significant variation within sectors, particularly in Scenarios 3 and 4. There will also be variation between regions of the EU because of the different employment and economic sectors. However, the potential trends across the sectors of the EU economy, excluding financial services, are shown in Table 5 in order of their relative value added to the EU economy in 2016.

General observations on Table 5 are:

- The major losses will be in medium-skilled jobs and the major gains in higher-skilled jobs. There will be a 'hollowing out' of the labour market.
- The areas that have the largest potential rates of job losses are manufacturing; distributive trades; and administration and support services. At the time of the writing of this report, these are the three largest employment sectors, representing over half of all EU jobs and also over half of total value added.
- The areas with the greatest potential for growth in jobs are professional, scientific and technical activities; information and communications; and repair of computers and household goods. In 2016, these amounted to 14 % of EU jobs and 14 % of total value added.
- There will be major changes in the nature of work and the distribution of jobs between sectors, which will create both challenges and opportunities, including OSH ones, for EU governments at all levels.

**Table 2: Cross-scenario analysis of the potential impacts of ICT-ETs on jobs in various sectors of the EU economy by 2025 (% given in the first column taken from Eurostat, 2017)**

| Sector and % of EU employment in 2016 | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| **Manufacturing**<br>**22 %** | Continuation of current trends in the growth of automation. Additional investment to address dangerous or unhealthy work. | Acceleration of automation trends, particularly for medium-skilled jobs, held by about half of the total employed. Priority is given to increasing the safety and quality of work. | A few areas exploit cheap labour, but most areas are investing heavily to save labour costs. Growing lights out manufacturing. | Most areas continue at current levels of automation. Higher investment is focused on areas where the greatest savings can be made, or arises from industrial disputes. Increased additive manufacturing in the grey economy. |
| **Distributive trades**<br>**24 %** | Modest reduction of numbers of jobs due to automation. Human contact seen as adding value to work in many areas. | Significant reduction in numbers of jobs due to automation. Face-to-face contact for premium services. | Large reduction in low- and medium-skilled jobs. Growth in higher-skilled jobs for automation and new business models, but the total number is small. Small numbers of fully automated workplaces with no employees on site. | This sector has the largest number of enterprises across the EU, including many smaller organisations that will undergo little change. However, the market share of these companies will be reduced by competition from highly automated start-ups. |
| **Professional, scientific and technical activities**<br>**9 %** | Only modest growth to support an increasingly technology-focused economy. | High growth to support rapid technological developments. Social science is given increased priority. | High growth, as science and technology are seen as an important competitive tool. | Little change, as increasing priority given to technology use is offset by limited investment in R&D, particularly by governments. |

| Sector and % of EU employment in 2016 | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| **Information and communications**<br>**4 %** | About half the jobs are high-skilled, and there will be modest growth in these. However, this is likely to be offset by a reduction in medium-skilled jobs. | The priority given to the DSM will result in strong growth in high-skilled jobs, which will more than offset the reduction in medium-skilled jobs. | Some sector areas will fall behind owing to limited investment, and others will increase rapidly to support high-investing companies. | Little change in the sector, as increasing developments in ICT are offset by limited investment in R&D, particularly by governments. |
| **Transport and storage**<br>**8 %** | Modest reduction due to automation of some vehicles in a few areas of transport and logistics-related tasks. However, this is largely offset by increased economic demand. | Significant reduction due to automation of driving in some transport areas and logistics-related tasks. This is partly offset by increased economic demand. | Large-scale automation of logistics tasks, and some autonomous distribution, particularly locally. | In most cases, there has been only modest automation, but there is competition from highly automated companies looking to reduce costs. |
| **Construction**<br>**9 %** | Owing to low levels of economic growth, there will be a reduction in construction and limited technological developments. | Economic growth will increase demand for construction. Automation will be used to increase productivity and quality. Investments will also be made in reducing construction risks. | Construction demand will be relatively level and investments primarily focused on reducing labour costs. | Demand will reduce, with greater emphasis on refurbishment and maintenance of properties, often carried out in the grey economy. |
| **Administration and support services**<br>**10 %** | Jobs are mainly medium-skilled and many tasks will be automated, with moderate investment. | Nearly all tasks could be automated, but this will be constrained to some degree by the recognition of the value of work, particularly in the public sector. | Administration and support services will be seen as too costly, so there will be a major increase in automation in this area. The remaining tasks will largely be sourced through crowd-working. | There will be a mixture of automation and cost reductions through lower wages and the use of online work platforms. |

| Sector and % of EU employment in 2016 | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| **Real estate activities**<br>**2 %** | A significant proportion of this sector will be automated. | Most of the sector will be automated; however, there will be growth in bespoke premium services. Many organisations will wish to maintain a 'face'. | Nearly entirely automated, except for bespoke premium services. | Almost fully automated, with limited demand for premium services. |
| **Electricity, gas, steam and air conditioning supply**<br>**1 %** | Limited further automation. Investment will be focused on reducing OSH risks. | Modest sector growth and automation to support infrastructure investment and increasing demand for electricity. Some investment to reduce OSH risks. | Modest growth in automation to reduce costs. Moderate growth in higher-skilled jobs in the sector, but a reduction in medium-skilled jobs. | Little change, with limited automation focused on cost reduction. |
| **Accommodation and food services**<br>**7 %** | Continuation of current growth in automation. Some jobs that could be automated will be retained because of the value placed on work and face-to-face contact. | Major investment in automation for routine services will result in an increase in higher-skilled jobs, replacing some of the lost low- and medium-skilled jobs. There will be more choice between automated and personal services. | There will be major losses in the medium-skilled jobs that make up well over half of all jobs in the sector. Provision of personalised services will be restricted to the top end of the market. | Cost cutting will drive a major loss of significantly more than half of medium-skilled jobs. Personalised services will be available only to the rich. |
| **Water supply, waste and remediation**<br>**2 %** | There will be limited further automation. Investment will be primarily focused on environmental benefits and reducing OSH risks. | Modest sector growth will occur to support environmental concerns. Investments will also be made to reduce OSH risks. | There will be a significant loss in medium-skilled jobs, but a slight growth in higher-skilled jobs. | There will be little change in the sector, as most companies will be making only essential investments. |
| **Mining and quarrying**<br>**1 %** | There will be little change in the sector. | Investment will be focused on removing people from hazardous environments | There will be limited investment, primarily focused on cost reduction. | There will be few changes in the sector. |

| Sector and % of EU employment in 2016 | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| **Repair of computers and personal and household goods**<br>**1 %** | There will be modest growth in the sector as a result of increased automation. | Major sectoral growth to support the DSM will occur. | Significant growth will occur in the sector to support increased automation. | Modest growth will occur as a result of moderate increases in automation. Some significant growth in the grey economy |

# 4 Scenario descriptions

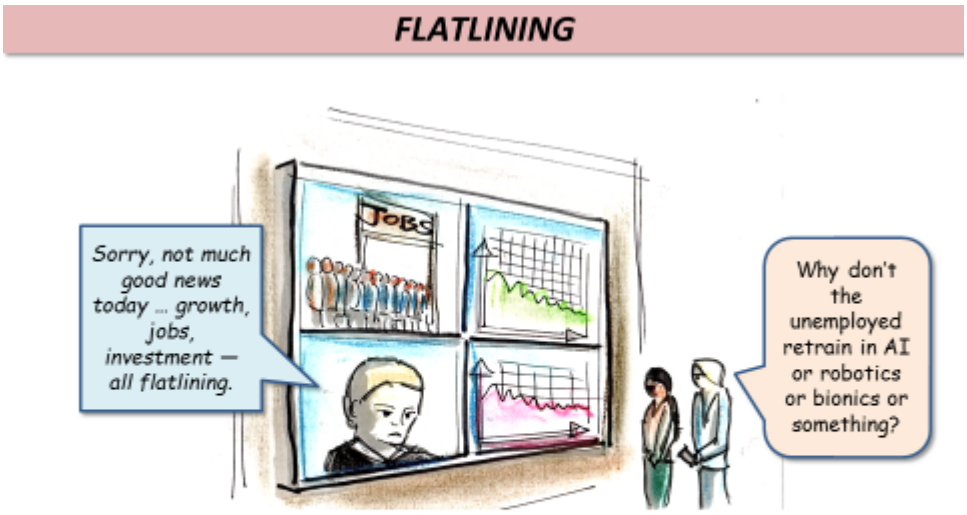
## Scenario 1 — Evolution

**(Low levels of economic growth and technology application / High levels of governance and supportive public/worker´s attitudes)**

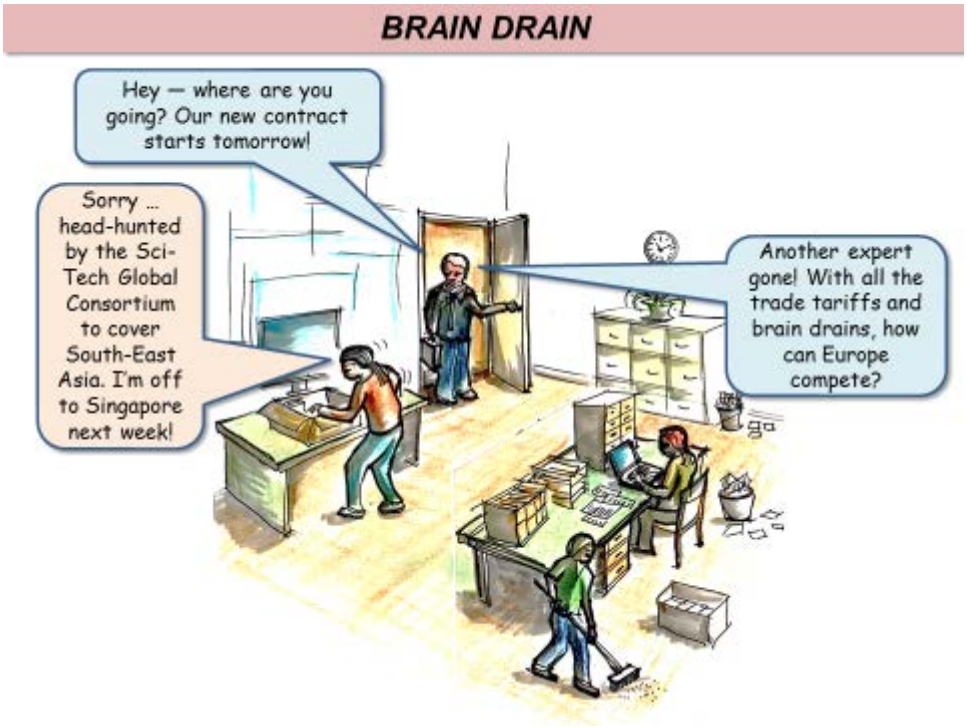
**Europe in 2025**

During a decade of low economic growth, the governments of Europe have sought to regain the trust of the voters and maintain social cohesion by focusing on workers' rights, social welfare, health and social care, and education. Employees, workers' representatives, business leaders and governments have worked together through social dialogue to build a consensus on the benefits of the exploitation of ICT-ETs at work. There is a mix of participation and trust management on the one hand and command and control on the other. This approach has been successful insofar as it has helped to maintain public confidence in government and new technology.

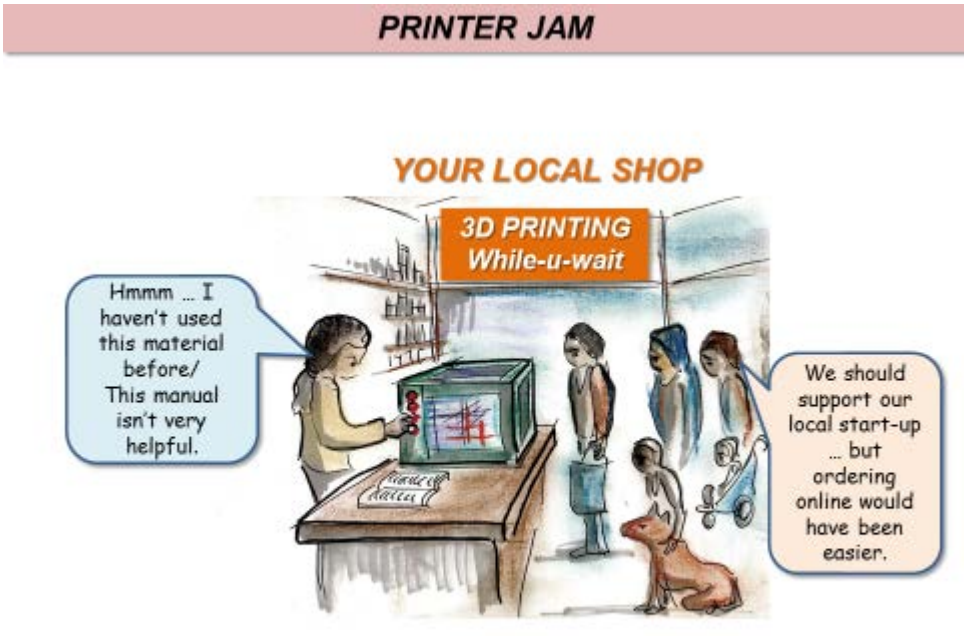
The slow pace of economic growth means that there have been limited funds for government and business investment in building the physical and research infrastructure required to support new technologies. Exploitation of these technologies has therefore been constrained, despite the acceptance of the potential benefits.




There have been continuing levels of relatively high unemployment and a loss of confidence in the benefits of international trade. In response to popular concerns, Europe seeks to protect its economies through strict trade and migration policies. However, there is global competition for highly skilled people who can work in a rapidly changing world driven by technological change, which has led to a 'brain drain' of people moving to faster-developing economies.




There is a mix of workplace innovation and more traditional work organisation, human resource management and labour relations. In some places, groups of people or local governments have formed their own micro-economic communities of interest and local enterprises. This is patchy, but where it has happened it is a positive response to the problems affecting Europe as a whole, and offers potential examples for others to follow.



By 2025, the richest few have increased their share of the total wealth. Most other people will be relatively poorer, with young people and middle-income workers particularly badly affected by the low economic growth. Although public sector jobs have been maintained, pay is generally poor, except in those areas where people have taken joint action to protect themselves and foster local micro-economies.

GDP growth remains low throughout the period, averaging around 1 % per annum. Businesses have been looking to survive and build a more secure future, and ICT investment is focused on areas where costs are lowest or where profits are highest. There are some parts of Europe that continue to do better than others because they started from a stronger position in terms of ICT infrastructure, investment, skills and adoption. There have not been the necessary Europe-wide strategies and investments to bridge the gaps, so they are widening.

Europe is not seen as a leader in new technologies. The speed of adoption of new technology, which is much lower than in the USA and parts of Asia, means that the rate of change in the labour market has been relatively low. Only about 10 % of jobs have disappeared, but about 40 % have been moderately changed by support from new technology. Real wages have fallen.

This relatively slow rate of change to work helps to maintain a sense of social solidarity, meaning that there is plenty of work for nurses and carers and in the public/state sectors.

The combination of the exodus of young potential high earners and new efforts to constrain immigration means that population projections are now pointing to a reduction in Europe's total working-age population, with further negative implications for GDP growth.

**Technological change**

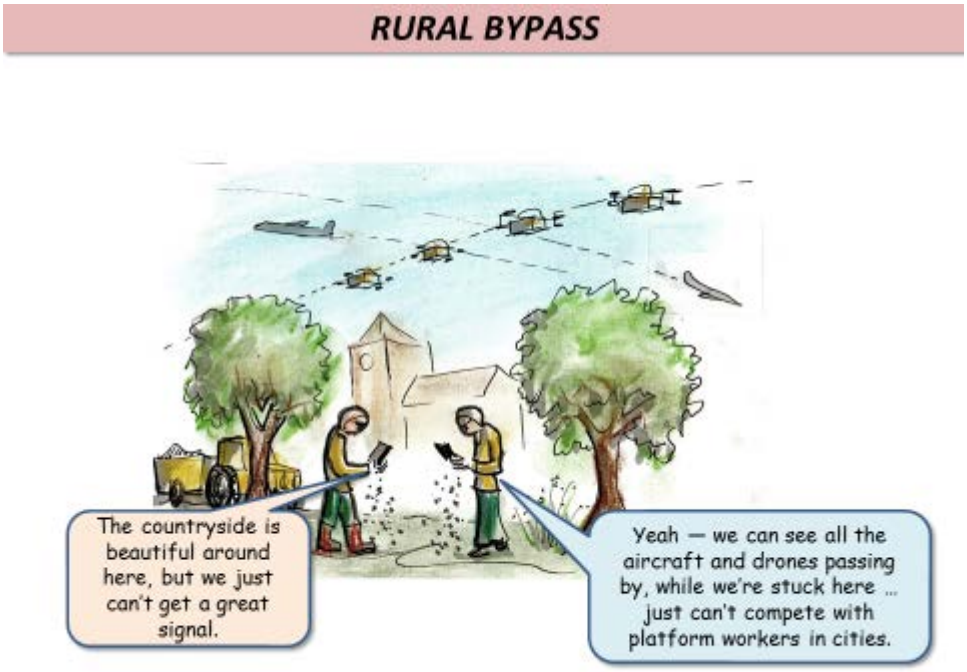
The application of new technology and skills has been slow and left mainly to the big international corporations, to motivated individuals or to local initiatives. The low levels of GDP growth and governments' focus on protecting 'old' jobs and maintaining social cohesion mean that a relatively low priority is given to research and development of new technologies. Global corporations continue to invest, but do so in the context of their own business strategies. Existing technology, which is seen as a more reliable and safer investment, is more widely diffused across sectors, whereas the pace of introduction of new technologies is quite slow.

There has been relatively slow development in cutting-edge technologies, such as AI, that drive the Internet of Things (IoT). 'The use of basic AI and voice control interfaces has increased moderately, but more advanced AI and human-machine interfaces (e.g. eye-tracking, gesture and direct brain to computer interfaces) are used only where they will significantly reduce costs. Examples include the management of more complex process and distribution systems. The majority of robots are still mainly undertaking repetitive tasks. Robots working collaboratively with humans or undertaking more complex tasks requiring greater dexterity are limited in number.

Additive manufacturing is beginning to disrupt traditional manufacturing industries and create new business models, including small start-ups.

Cyber-attacks have increased and are a serious threat, as it has not been possible to finance the increasingly high levels of investment needed to counter them.

The use of online work platforms has steadily increased during the decade, particularly where micro-economic communities exist. 5G broadband has been rolled out across the urban areas of the EU, but access in most remote regions is still limited. As a result, some people in more remote areas have been excluded from the growth in mobile and home working and the online labour market.




**OSH environment**

The priority for the private sector is staying in business and for the public sector it is reducing and dealing with the issues associated with unemployment. Governments support workers' rights and work with the social partners to ensure that OSH is seen as important, using a consultative approach to work within the constraint that there are limited funds and resources for OSH regulation, research and training. The increase in the numbers of self-employed and online platform workers has removed a significant proportion of workers from regulatory oversight.

There are pockets of good OSH practice, but the loss of management jobs has fundamentally changed employment hierarchies and worker relationships, which can be detrimental to good OSH management. The tendency for existing technologies to be widely diffused, rather than for new technologies to be rapidly adopted, means that OSH hazards and their prevention are generally well known. The manageable pace of change means that OSH regulation is generally able to keep up and there are opportunities for OSH hazards to be designed out and for best practices to be shared before the technologies to which they apply are in widespread use. Social media is also used to disseminate information on OSH issues.

A gradual but patchy increase in levels of automation, use of robotics and use of AR and VR removes some people from hazardous working environments. However, some of these technologies may not be well maintained owing to businesses' constrained finances and/or understanding of the risks. Connected robots/machines could also be vulnerable to cyber-attacks that could cause them to malfunction in a hazardous way.

There is a risk of work-related stress due, for example, to being monitored at work, working alongside robots or, in some sectors, job insecurity. However, wearable technology is also used to help individuals monitor and manage stress.

## Scenario 2 — Transformation

**(High levels of economic growth and technology application / High levels of governance and supportive public/worker´s attitudes)**

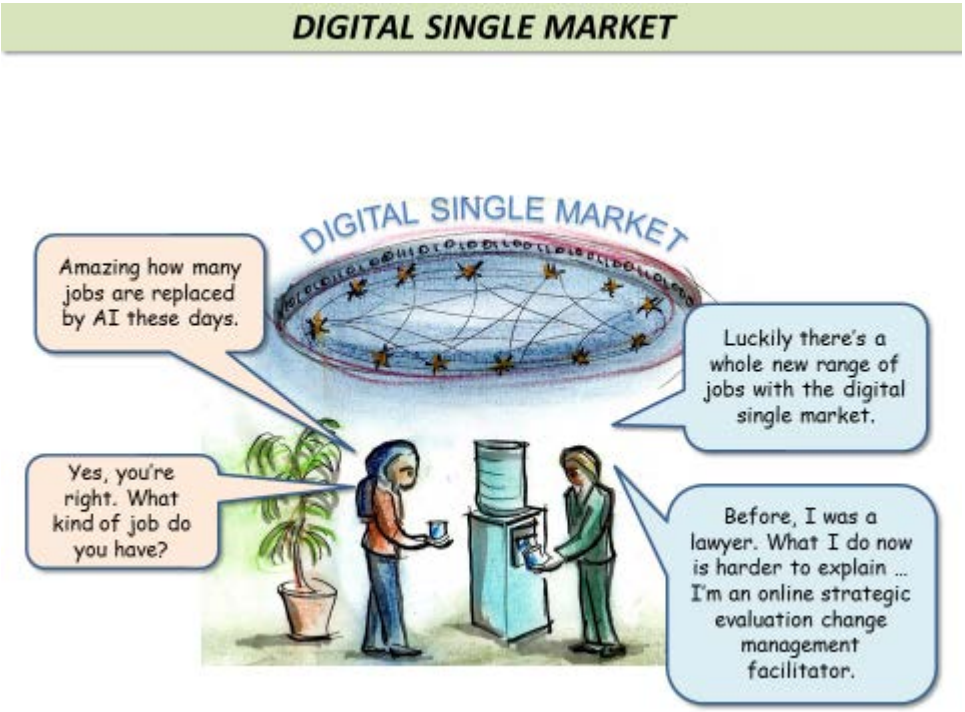
**Europe in 2025**

The political and social landscape of Europe has undergone a transformation, becoming one that is more collaborative, consensual and ethical. Policy-making is evidence-based, responsive and resilient. Under this new 'social contract', acceptable behaviour is reinforced through social norms and values.

An increasingly connected, environmentally and socially aware public embraces new technology. Workers (and people more generally) use ICT very effectively to create radical new and innovative ways of organising labour so that, in general, no group is particularly disadvantaged. Mechanisms are available to make governments accountable over a wide range of issues, including the regulation of new technology, online privacy, healthy and sustainable work practices and care for the environment. This creates, among most, a high level of trust in policy-makers, and, in general, an acceptance of new technology. Society is also less discriminatory and more equal, as ICT supports workers irrespective of their demographic (e.g. age or class).

Political alliances, established during the successful implementation of the European Digital Single Market, have resulted in governments across Europe working well together. Governments have embraced the efficiencies offered by ICT-enabled technologies and have found innovative ways of regulating new technologies and working patterns. They have the necessary funds and the knowledge to support sound investments in infrastructure, cyber-security, education and training. This enables ongoing technological change and economic growth of 3 % to be sustained.

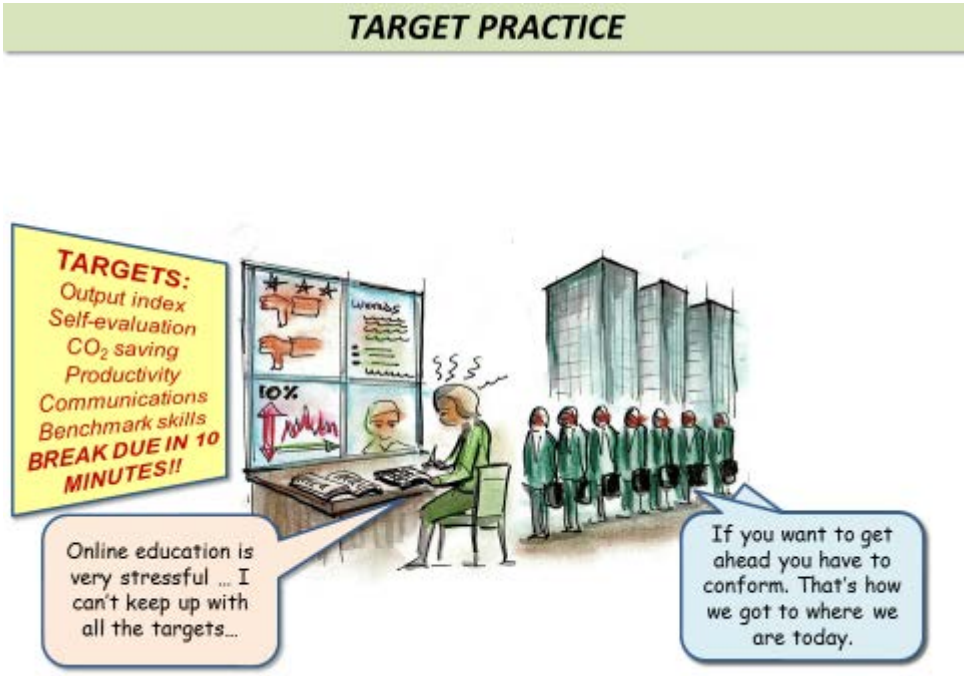
The labour market is characterised by frequent changes in the type and nature of jobs available. During the past 10 years, 50 % of jobs have fundamentally changed or disappeared, with many new jobs being created. It is common for workers to have several jobs that fit around their personal lives. There is a complete blurring of work and personal life, with people moving almost seamlessly between one and the other. The majority of workers are capable of protecting their work-life balance, which is supported by Artificial Intelligence (AI) supervisory algorithms built into work interfaces. People also change jobs frequently and with ease, and often continue to work healthily into their 80s. Average life expectancy is 100.



Unemployment remains generally low owing to widespread good-quality skills among workers, innovative job search tools and new jobs replacing lost ones. Workers' disposable income is generally good, with less disparity between most people. This has created high levels of migration into Europe.

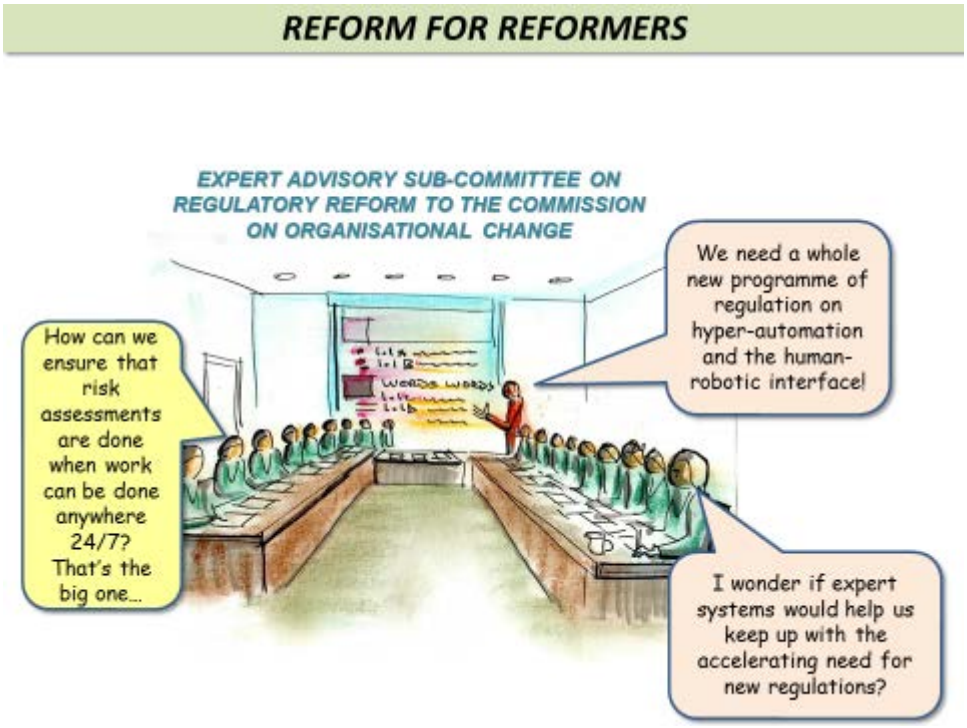
There has been a fundamental change in the underlying principles, structure and control of the internet, including the creation of a digital version of the Geneva Convention. Despite this, cyber-security is an increasingly important and challenging job.

The approach to education and training has been transformed. Human-trainer-led teaching is blended with high-quality interactive Massive Open Online Courses (MOOCs), which are widely available. Quality is assured through accreditation by online worker cooperatives, employment associations and trade unions. Workers, employers and governments all recognise the importance of lifelong learning. Good-quality ICT skills, as well as interpersonal skills, are, therefore, kept up to date across the wide demographic of workers.




There is an expectation that people will comply with social norms driven (in part) by insurance and employment implications. Most workers are comfortable with this. For those who are not, it has led to a feeling that they have lost their sense of identity, as they are rarely completely free from being assisted and monitored by AI algorithms, which record attendance, performance and productivity. This has created an underclass of people living on the fringes of society, who don't want to be permanently monitored by ICT-ETs, are 'disconnected' and have lost access to many work opportunities and services that rely on ICT.

The pace of change (technological change and changes in ways of working) is moderated by the need to reach consensus among the social partners, which can sometimes slow down decision-making.




**Technological change**

5G broadband was rolled out across Europe some time ago, including in rural areas. The Internet of Things (IoT) is widespread, such that most devices at work and at home are smart and connected.

The use of basic, narrow AI is part of many aspects of people's personal life and work, and most people work in teams supported and advised by AI systems. This helps workers to be more productive, by removing the routine aspects of jobs. For example, health workers are provided with patient information and a likely prognosis by an AI system. Workers are generally monitored and directed by learning AI systems, which help to manage stress, promote well-being and encourage safer, more productive working practices. These AI systems assess a range of data from the worker, including physiological data collected through wearable devices.

Artificial general intelligence (AGI) is beginning to replace higher-skilled jobs across a range of sectors. In some areas of work, AGI is recognised as being better at data analysis and running processes and systems than humans. These AGI machines now make decisions and act upon them without human supervision or intervention. However, there are some concerns around how much control AGI machines have and how they make decisions.

Empathy algorithms are used to tailor the nature and format of advice according to the varying needs of different users.

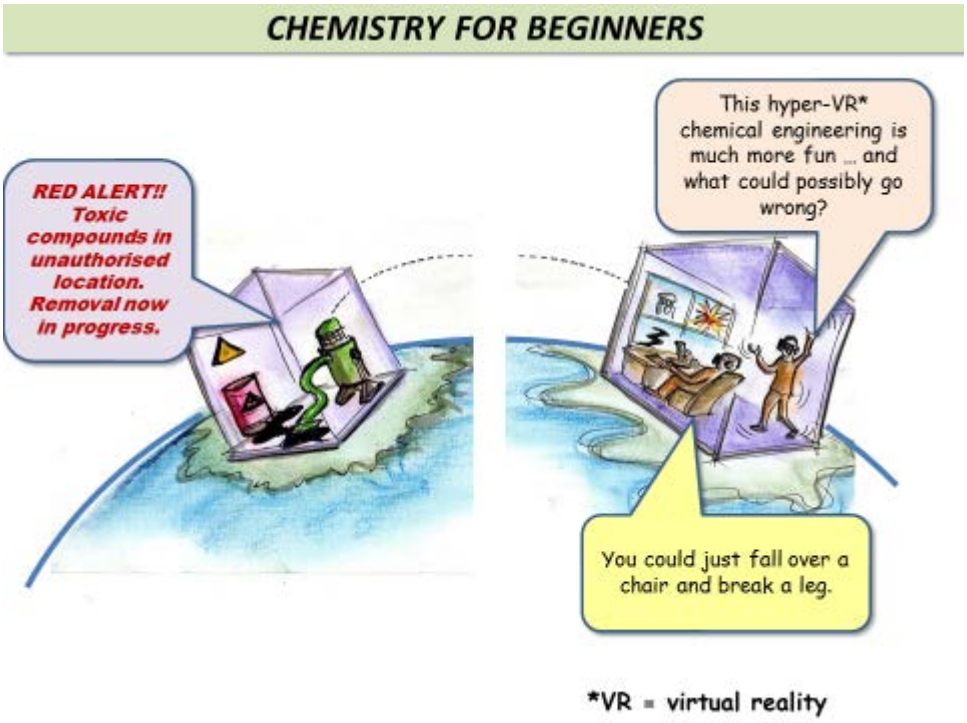
Interfacing with ICT (and other people remotely) is more natural and immersive. There is widespread use of voice recognition, eye tracking and gesture control. The use of direct brain-to-computer interfaces, while not widespread, is no longer seen as niche.

Additive manufacturing has created new business models, such as bespoke local on-demand manufacturing.

Self-driving autonomous cars and other means of transport (including drones) are common and car ownership is low.

There are significant numbers of fully autonomous robots that can undertake complex tasks, including those requiring high dexterity.

'Lights out' manufacturing is quite common in several industrial sectors; many factories are fully automated with no or minimal remote human supervision or intervention.




**OSH environment**

Good OSH is a priority for all social partners, driven by ethics and recognised as good for a sustainable society and business. This has created a culture of continuous improvement, common standards and effective self-regulation. Social norms promote good OSH management along with safe and healthy behaviour on the part of workers.

The new social contract means that there are trust, transparency, shared values and openness between governments and social partners, which encourages collaboration on OSH. There is also a preference for a consensual, evidence-based approach to decision-making, with governments made accountable by well-coordinated direct action by social partners. Work organisation mirrors this, generally following a participation and trust management regime. This has allowed innovative partnership, workplace innovation, and ICT-based approaches to regulation to be implemented.

There is funding for good-quality OSH research, with access to large quantities of relevant data as a result of the widespread use of wearables and from the IoT. Consequently, OSH tends to be built into ICT enabled technology and work processes. Therefore, on the whole, there is resilience to the moderately rapid pace of change (technological change and changes in ways of working). However, a consensual approach can occasionally lead to a lack of efficiency and an overly precautionary approach. Regulation can also sometimes lag behind the introduction of new technology.

Social norms can cause stress/anxiety from the pressure and/or need to conform; some individuals worry that they are not able to perform or behave well enough to meet societal expectations. The pressure to conform can also sometimes lead to ‘group-think’, such that emerging risks are missed.

Organisations and regulators, in general, have the knowledge and skills to manage OSH effectively. The working environment in Europe attracts and retains motivated, experienced and highly skilled workers. This, along with the open intellectual property movement and good-quality, innovative approaches to training and knowledge transfer, mitigates the impact of workers having several jobs and changing them regularly.

However, changes in employment patterns and hierarchies can mean that there is a lack of clarity about who is responsible for OSH, particularly where work is done via online platforms or where workers have AI bosses. Some workers may also fall outside formal regulation because of their employment status or because their location is hidden behind an online platform. Most people work short-term contracts for different companies around the world, or do small jobs or tasks through online platforms.

Generally, people work alongside AI systems or 'cobots', and many are supervised, assessed, coached managed and monitored by AI. This can put excessive cognitive load on some individuals. Others suffer stress/anxiety due to the loss of control or responsibility and peer support at work or are concerned about how much they are monitored.

There are not many fixed places of work, and the realistic nature of VR and AR mean that most people work from home, in shared communal spaces or in public places. Most work meetings are held in virtual reality and, while this improves efficiency and reduces travel costs, some feel a lack of real social interaction and support. Homes, public spaces and means of transport have, in general, evolved to be more worker-friendly from an ergonomic perspective. Human-machine interfaces are generally more ergonomic, but new ways of interfacing may result in new cognitive, voice, visual and MSD risks.

Increasing levels of automation and use of robotics remove many workers from hazardous physical, chemical and biological working environments. AR and VR are used for immersive training and to support maintenance tasks, which can often be done remotely; this also contributes to removing workers from hazardous environments, but can cause cognitive issues and disorientation between the real and virtual worlds and occasionally accidents happen. Where people need to work in hazardous environments they are protected by smart PPE that can alert users to exposure to hazardous substances and tailor advice to the needs of the user. In addition DNA profiling can be used to screen out workers who are susceptible to certain chemicals or allergens.

The use of autonomous vehicles, bionics and exoskeletons enables an ageing population to continue to work. However, their use may cause loss of bone or muscle density and/or joint flexibility.

Good cyber-security and ICT reliability are essential because of the number of online smart devices and dependence on networked ICT systems for many work activities; if hacked, these systems could cause hazardous malfunctions.

Despite this, technology is, on the whole, very reliable and work processes are generally safer. However, when something does go wrong it can take time to realise that there is a problem and workers will have little or no experience on which to rely when deciding how to manage the situation (because technology rarely goes wrong). This can be exacerbated by the fact that many work processes are remotely supervised by just a few workers, who may have little to do most of the time.

People are generally better able to balance personal and work-related demands due to the highly flexible nature of most work. In addition, AI supervisory algorithms are built into work interfaces to prevent unhealthy working practices. However, stress can still be an issue for some people because of the temptation to work intensely; the blurring of work and private life; increased task complexity; being continually monitored; the expectation to conform; and the loss of human interaction at work. As a consequence of automation, robotisation and AI, some workers may also suffer from stress due to task deprivation, for example not having enough to do, their job being monotonous or their job not requiring them to use their cognitive skills.

# Scenario 3 — Exploitation

### (High levels of economic growth and technology application / Low levels of governance and resistive public/worker´s attitudes)

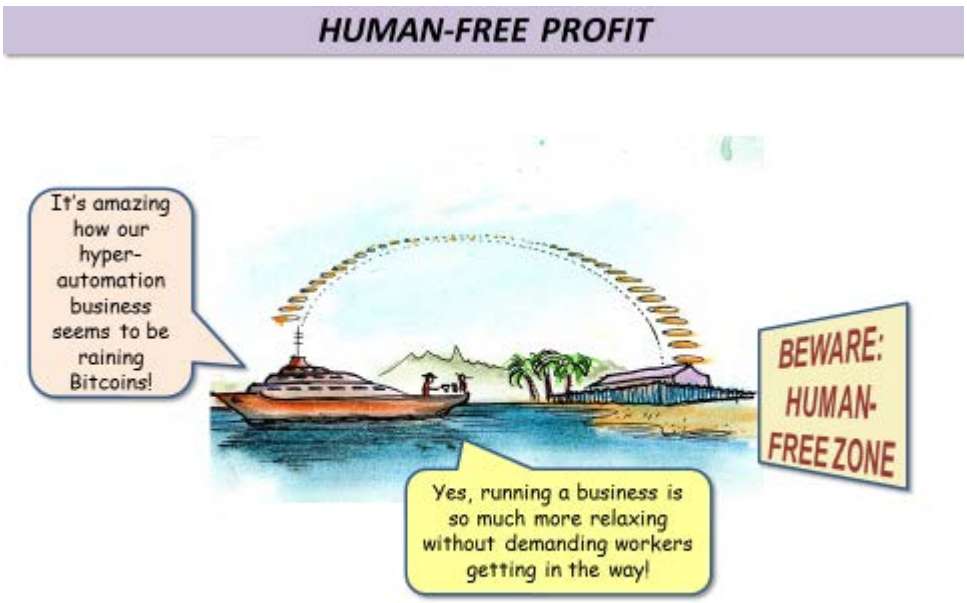
**Europe in 2025**

Annual economic growth has risen during the past 5 years to about 3 % of GDP, with increased business investment in research and development, infrastructure and capital assets. Market forces and rapid technological change lead to enforced adaptation by the workforce. During the last decade, the social partners and governments have generally failed to work together and have lacked the resources to ensure that regulatory frameworks keep up with the rapid pace of changes in ICT-ETs and the changes they have triggered in relation to (flexible) employment, working arrangements, the nature of work and work location. This has included an inability to modernise the collection of taxes, starving governments of the necessary funding for education, skills, infrastructure, and research and development.

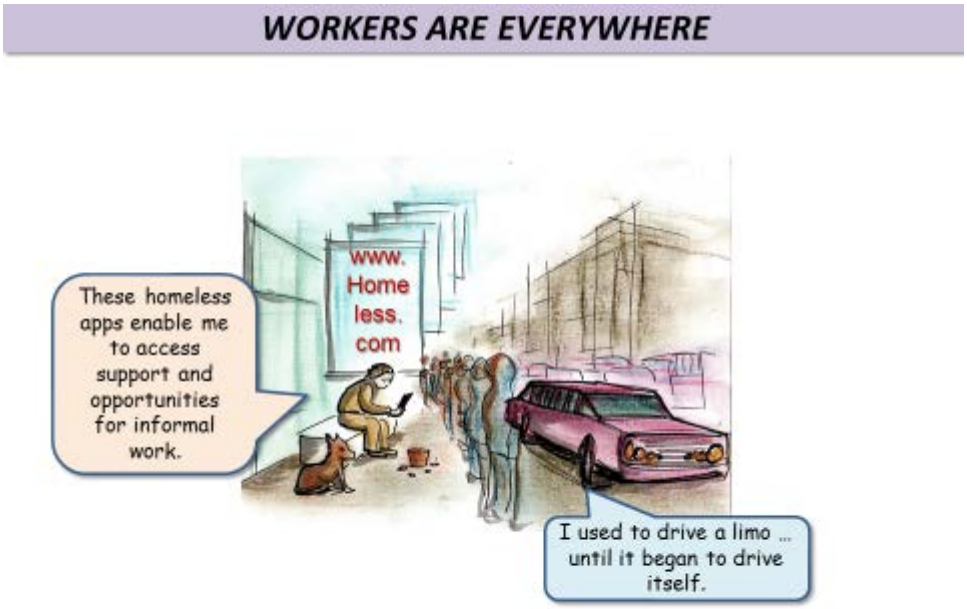
ICT skills are funded where there is an immediate need or where skills cannot be brought in through online platforms or offshored. Businesses are mostly doing well and seek to maintain their positions by investing in research and development to maximise technology exploitation, primarily in the areas that yield the quickest and greatest profits. However, disruptive ICT-ETs can put companies out of business quite suddenly, despite national governments' interventions to try to protect their workers' jobs.

Rapid advances in ICT have had a widespread and profound impact on work. There is an increasing rate of change in the European labour market. The economy is dominated by increased freelancing, zero-hours contracts and short-term contracts (the so-called gig economy). Many people work for at least five employers at any one time, are enrolled with a number of online platforms and frequently change jobs. About 60 % of jobs have fundamentally changed or been lost. Of these, around 40 % of jobs have been lost because of the automation of routine and repetitive work activities. The societal benefits of work are not valued and only about 10 % of jobs are newly created. The available work is primarily unskilled, with only a small proportion of partly standardised high-skilled work.

There are very high levels of unemployment and much greater inequality between the high and low paid. Workers' interests and their training are lower priorities, as it is easy to buy in skills as required. What jobs there are are generally unstable and insecure in nature, and work is often challenging and intense.



There is a 'digital divide' between the 'haves' (highly skilled individuals who compete for the best jobs) and the 'have-nots' (unemployed or in precarious employment). There has been a decline in public trust and workers' rights, and a lack of government leadership. Those still in work feel threatened by the ongoing rapid pace of ICT developments. There has been a continuing decline in trade union membership and a resulting lack of collective bargaining power. By 2025, workers' discontent is high and there is ongoing unrest. Protests, including direct action, coordinated and mobilised via social media, are common.

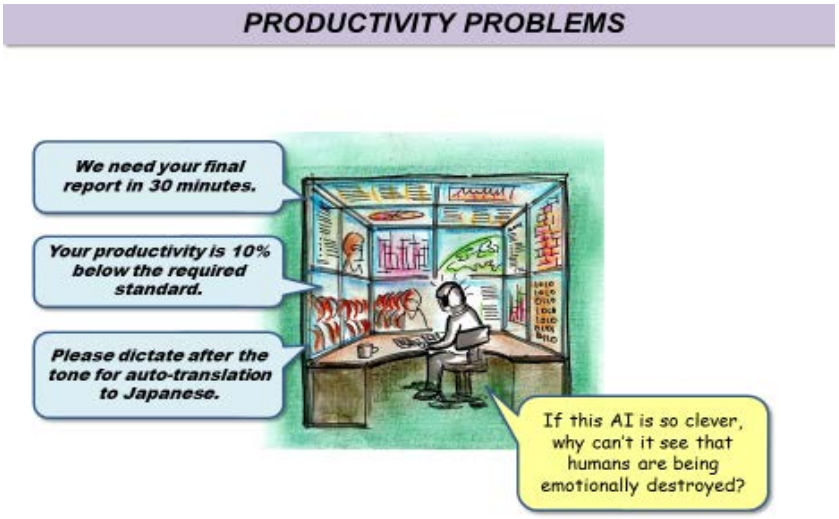



As a result of significant ICT skills gaps towards the beginning of the decade, businesses attempted to upskill the workers needed to use advanced ICT-ETs. This means that there are opportunities for less wealthy EU countries to benefit from the ICT revolution. Increasingly individuals use widely available Massive Open Online Courses (MOOCs) to upskill themselves. This leads to a rise in social mobility for some. However, the demand for high-level ICT skills still outstrips supply, so there are high wages available for those with the best skills. Job opportunities are increasingly dependent on having good ICT skills. Creative/artisan and interpersonal skills are also highly valued. However, use of online training also means that wider skills, for example social skills, can be poor. High value is attached to education and training for those who can afford it or borrow money to pay for it. Face-to-face training is primarily available to only the most affluent workers.

**Technological change**

There is limited choice for workers in this scenario; technology will be 'done to you' rather than 'be there for you'.

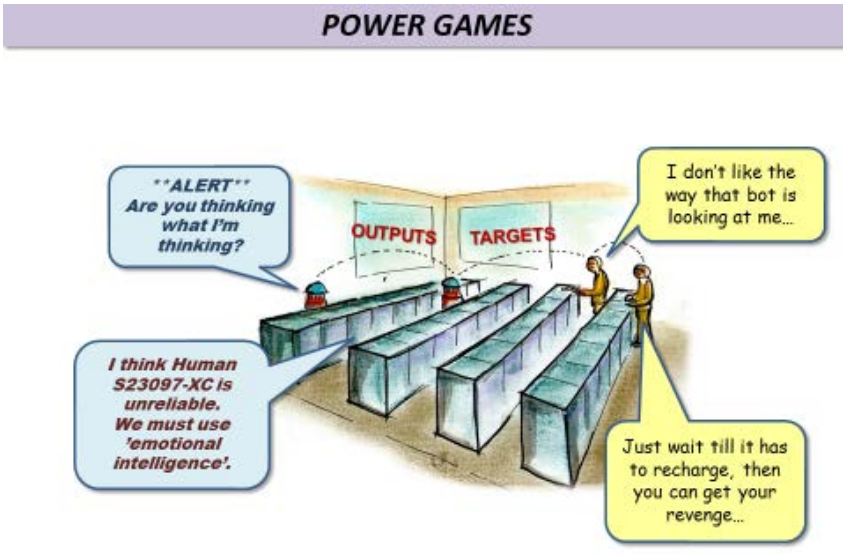
Advances in AI and robotics are ubiquitous in the workplace. Businesses have realised the improvements AI can bring to productivity and efficiency, and systems have now been widely adopted to direct, monitor and assess worker performance and productivity. Management is usually of a command and control nature, overseen by AI supervisors.




Robots and computer algorithms now carry out the majority of routine and repetitive tasks. Skilled professional jobs have also been significantly affected. Robots commonly work collaboratively with humans and can undertake increasingly complex and powerful tasks. Biomechanical devices, such as exoskeletons, are commonly used in workplaces, for example in care work, maintenance and logistics. However, there are issues around the security and control of biomechanical devices, particularly smart devices that are connected to the Internet of Things (IoT).

Interfaces using voice recognition, eye tracking and gesture control are common in some sectors, and there has been early adoption of direct brain-to-computer interfaces. Traditional large manufacturing activities have been significantly disrupted by additive manufacturing; small and medium-sized enterprises and start-ups increasingly provide products locally.

The IoT is now part of most aspects of daily life and most workers are monitored constantly online and via IoT-connected wearables. However, there is patchy coverage across Europe, with many rural areas lacking access. Internet profiling of prospective and current workers by businesses, including during their leisure time, is routine (to monitor for a healthy lifestyle, valued because of the link to productivity benefits).




Throughout the decade, cyber-attacks have been increasingly common, because of the lack of a robust, coordinated response to the threat from both governments and businesses. This has resulted in a greater loss of public trust. Infrastructure, power and utilities have all been disrupted by cyber-attacks, and this is now part of everyday life.

**OSH environment**

A lack of government leadership, public trust and dialogue, or support from business, means that regulatory frameworks are generally inadequate and unable to keep up with the rapid pace of change in ICT and working patterns. This is exacerbated by a lack of effective collective bargaining for good working conditions, due to falling trade union membership and limited access to alternative bargaining approaches.

There is patchy investment in OSH research and training and poor access to good-quality OSH information. Workers frequently change jobs, do not have the time or money for quality training, and experience extended periods of unemployment. Employers commonly transfer responsibility for OSH management onto their workers through pseudo self-employment contracts. The precarious nature of work can also create a willingness to accept OSH risks, just to be able to work.

The workforce is dispersed and rarely engaged in a traditional employer-employee relationship. For example, most workers are self-employed, with precarious employment contracts (zero-hour contracts, on-call work, online platform work), often taking multiple and/or short-term jobs. This has a detrimental impact on OSH outcomes. One example of this is the lack of implementation and enforcement of any OSH legislation or health surveillance.

Social media is used to form collectives, which attempt to use their combined power to improve working conditions, with occasional but often limited success. AI 'assistants' are also provided by the better online work platforms, to promote OSH information to workers. As a result, there is a considerable contrast between good and bad jobs in terms of OSH.

Increasing levels of robotics and use of automation remove many people from hazardous physical, chemical and biological working environments. However, workers generally have to adjust their speed or position in order to work effectively with collaborative robots. This pressure to perform at the same level as robots can cause stress and MSD issues as a result of poor ergonomics or working too fast.

The combination of new technology and older technology can lead to OSH risks, for example if an individual comes across an older robot and expects it to behave in the same way as an intelligent, sensing collaborative robot.

Some OSH issues are offshored along with the work. However, there is still a need for 'dirty' work in some areas that are currently too difficult to automate fully or where human workers are still cheaper. For those working in these environments, there is the potential for exposure to a wider range of, and more chemically complex, materials, for example during manufacture or recycling. New materials are also being used for 3D and 4D printing and bio-printing in small shops and start-ups by owners and their workers, who may have little training in the risks posed by exposure to toxic particles/fumes or explosion/fire hazards.

Technology is increasingly complex and brought to market quickly, which can lead to potentially hazardous design flaws that are difficult to spot. A lack of investment in cyber-security and internet infrastructure also means that work equipment is susceptible to malfunctioning owing to hacking in ways that can cause hazardous situations in the workplace, for example the shutting down of cooling systems used in exothermic chemical processes.

Human-machine interfaces are ubiquitous and some are personalised to the user. However, many are not adapted to the cognitive level or other needs of workers. New ways of interfacing may also result in new cognitive, voice, visual and MSD hazards.

Overall, work-related stress, anxiety and depression are common because of the precarious nature of most jobs, job insecurity, work intensification, working for multiple employers, continual monitoring, working alongside robots and pressure from AI systems to increase productivity (known by some as the 'digital whip'). Cyber-bullying is also common in many workplaces, across many sectors.

Lots of people, despite their self-employed status, feel 'owned' by their 'employers', are expected to be available for work at very short notice and suffer from conflicting employer demands. It is easy for individuals to over-work and many workers burn out.

## Scenario 4 — Fragmentation

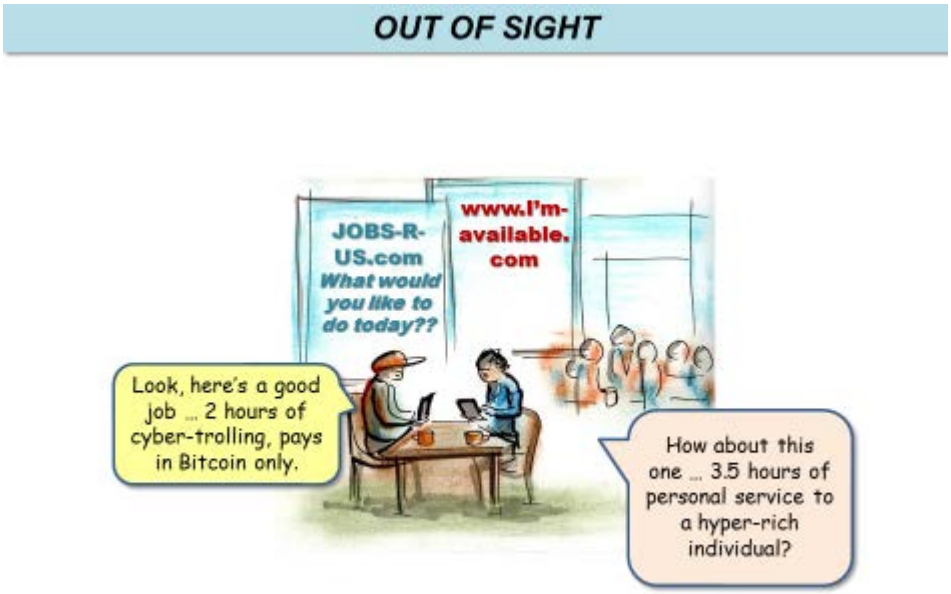
**(Low levels of economic growth and technology application / Low levels of governance and resistive public/worker´s attitudes)**

**Europe in 2025**

Europe has endured a decade of low growth and low technological development in most sectors of the economy. There are low levels of social cohesion and most people are motivated by self-interest. The economy is typified by short-termism, low wages, low tax revenues and high inequality. Only those businesses and workers who are the 'fittest' survive. There are high levels of informal work in the grey economy, often based on local or personal relationships, often facilitated by social media.

Ethics have come under pressure, as tax avoidance has become the norm and governments' ability to regulate new working patterns has diminished. Both businesses and individuals working in the grey economy see avoiding tax as 'smart', or at least, sensible. The concept of loyalty to one's company or workforce has virtually disappeared. Traditional models of hierarchical command and control management and human resource management have generally broken down. The lack of tax revenues means there is limited government spending on social welfare and health. Deregulation pressures have led to a 'small state' ethos. There are high levels of unemployment, at least in the formal economy, and many of those in work need at least two jobs to sustain themselves. Job insecurity is widespread, with zero-hours contracts common. The ageing population has no choice but to remain in work longer and older workers tend to have to accept lower value jobs as their previous jobs disappear.

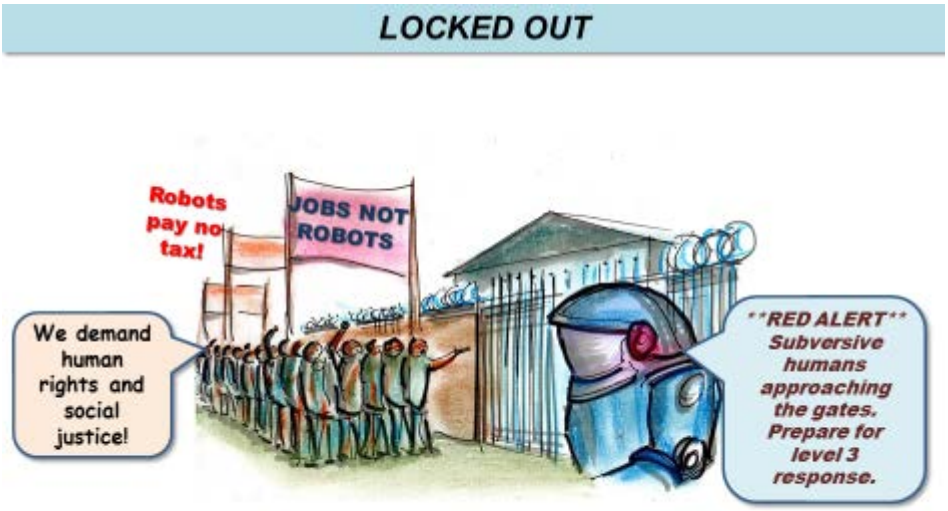
Governments have done little to support innovation. Businesses have exploited developments in technology with a narrow focus on short-term profit, and 'productivity' in the form of the replacement of labour, or by using AI supervisors to drive increased efficiency. In some cases, industrial disputes against automation have actually resulted in its implementation being sped up to restore reliable services to customers. Some well-paid, high-status roles remain, so there is still a segment of society that can afford high-quality personalised services.




GDP growth throughout the period remains low, at about 1 % per annum at best. Investments by both business and government in research, infrastructure and skills development are generally very low, and incremental improvements are seen as the most cost-effective way of reducing labour costs. However, there have been some significant examples of the successful application of ICT, particularly by the owners of online work platforms to support the gig economy.

Around 20 % of jobs have been lost during the decade, mainly to the automation of low-skilled, repetitive work. Few new (formal) jobs have been created. Most people change jobs frequently as they are pushed out. New job opportunities tend to be lower paid and short term.

Lack of trust that the benefits of new technologies will benefit workers or be spread evenly across the population has led to a high level of resistance to change. While technological change has continued, the rate is, in most cases, steady rather than rapid. More traditional industries (e.g. engineering, retail) continue to exist, but with decreasing profitability. Limited innovation is focused on greater exploitation of both human and environmental resources.




Faith in governments' ability to shape the future has all but vanished and ever fewer people vote or participate in civic society. An 'every person for themselves' attitude prevails, particularly in the formal economy. However, there is still a place for personal contacts and relationships to provide mutual support in some parts of the grey economy. Some see the greater personal freedom and limited state intervention as a positive development.

There is low investment in the maintenance of both equipment and software, leading to more frequent failures, greater numbers of cyber-attacks and consequently even greater loss of public trust.

Low investment in education and training has also created a workforce where only some have the skills to fully exploit advanced technologies. Massive Open Online Courses (MOOCs) are available, but they are of variable quality, so they improve skills only to some extent. Use of online training also means that wider skills, for example social skills, can be poor. All this has combined to hold back innovation in many businesses. The polarisation of society, therefore, continues to increase, with rich individuals and a few successful businesses able to sequester greater shares of national wealth, and a growing underclass turning to increasingly illicit ways of surviving.

**Technological change**

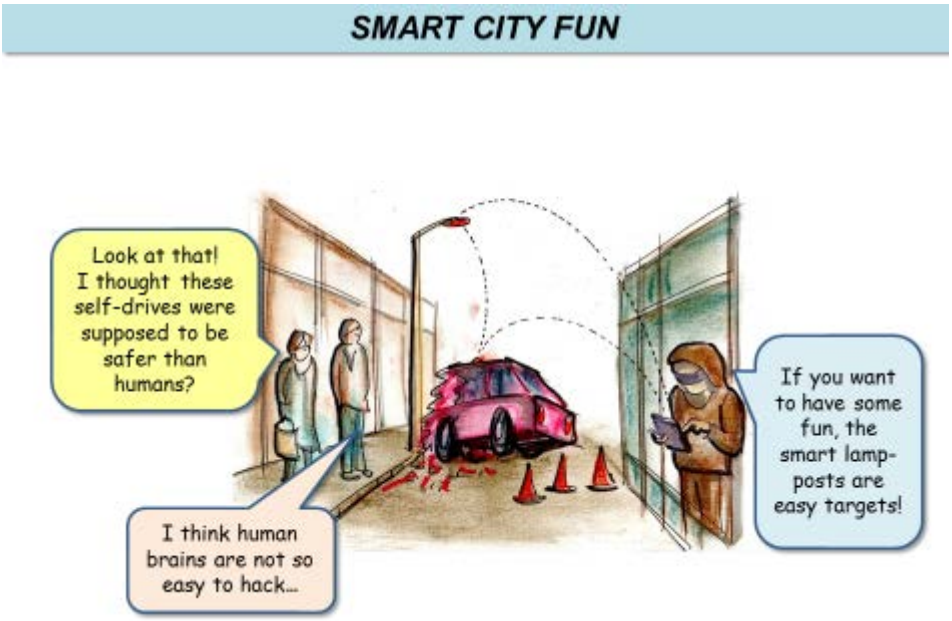
The wave of technological developments that was in the pipeline at the beginning of the decade has been harnessed for short-term profit but innovation has been limited. Automation has replaced significant numbers of routine repetitive jobs, particularly manual ones in the manufacturing and construction sectors. Drones and autonomous vehicles are becoming fairly common.

Investment in mobile networks has been limited and 5G is focused on profitable areas, generally industrial areas and cities. The Internet of things (IoT) is now part of many aspects of our daily lives, including work, so we are almost never free from 'supervision.' However, limited investments in networks and cyber-security have led to increased cyber-crime and restricted data sharing.

Monitoring technologies, including through mobile devices, are increasingly used to ensure workers are working as hard as possible, and to remove those seen as not performing well enough.

Additive manufacturing is beginning to disrupt traditional manufacturing industries and create new business models, including small start-ups.

The development of robots undertaking more complex tasks that require greater dexterity has continued but is not widespread. Robots working collaboratively with humans are more widespread and the use of bionics has increased where productivity gains can be made. The effective use of big data has enabled fairly widespread use of basic, narrow AI, which has significantly changed some jobs and replaced routine clerical ones.




There has been a large increase in online work platforms that provide a wide variety of work, from highly skilled professional work to small, routine tasks. Work is carried out online or offline (but managed online), in varied work locations, and most workers are (pseudo) self-employed. Numerous individuals are on zero-hours contracts and the insecure nature of work (e.g. with workers being called to jobs on a just-in-time basis) means that many suffer from stress and anxiety. Work is often intense, which contributes to both psychosocial and physical disorders. A large amount of the available work is computer-based, which has led to an increase in physical disorders such as MSDs. Some of the online platform work available is in typically dangerous occupations such as forestry. Because most individuals are (pseudo) self-employed, the responsibility for safety and health is transferred from the employer to the worker. Many lack employment benefits such as sick pay.

In addition, a wide range of new online jobs has been created, such as crowdfunding specialists and personal digital curators.

**OSH environment**

Despite occasional public outcry at disasters, governments struggle to impose or enforce regulations, not least because there are limited tax revenues available to fund enforcement. Indeed, in the name of 'cutting red tape', some regulations have been relaxed and OSH is not well viewed generally. The effects often have a delayed impact, so are not seen for a number of years.

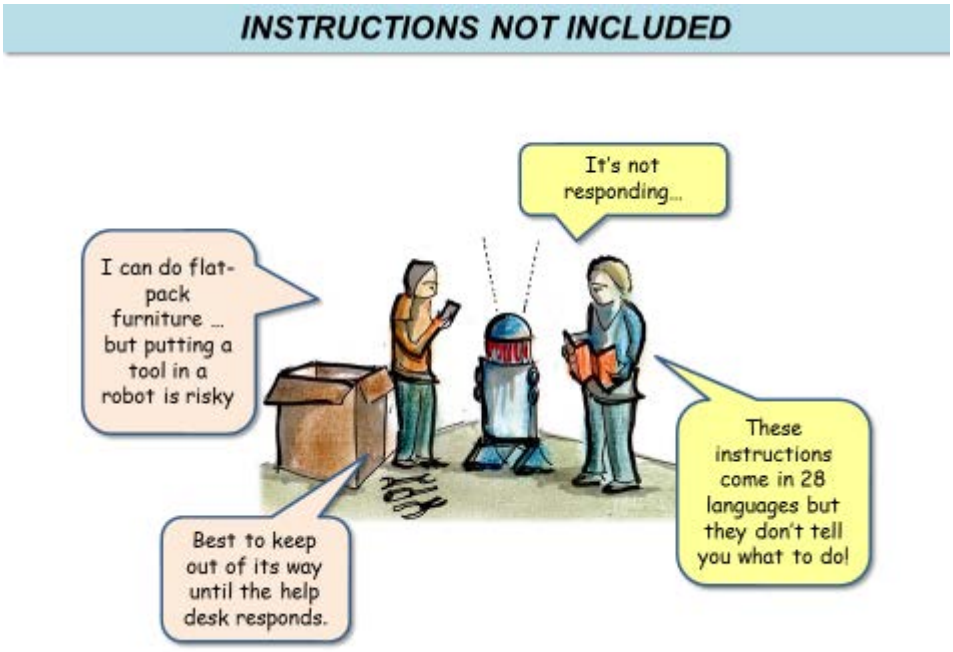
The overall slow pace of change means that in most areas OSH regulation is adequate and little changed, but it can struggle to keep up with pockets of high innovation. This variation across and within sectors makes the transfer of OSH knowledge from one workplace to another more difficult.

The unregulated grey economy is fraught with potential OSH risks and is very difficult to monitor and control. The safety of work processes and the quality of products or advice services cannot be assured, as corners

are cut in an attempt to make profits or keep prices low enough to be viable. Extensive sub-contracting also blurs responsibility for compliance with OSH regulations, and responsibility for OSH is transferred to the worker in some sectors. Under-investment, by governments and businesses, in cyber-security has led to more cyber-crime, which can shut down or compromise safety systems.

Companies focusing on short-term profits have consistently under-invested in OSH systems, so the number of equipment failures and the incidence of injuries and work-related ill-health remains high. Organisations invest little in OSH training and many workers have poor access to good-quality OSH information. In addition, workers often experience extended periods of unemployment. Overall, this means that many individuals lack adequate OSH knowledge and work experience, and as a result are at greater risk of harm at work.

A make-do-and-mend culture, with a mix of old and new assets, creates OSH risks arising from the integration of the new with the old, and at the interfaces between the two. The tendency to run old systems until they break down also increases OSH risks.




The use of AR and VR has increased for training and to improve productivity. However, there is little new innovation in the underlying technology. The use of these technologies has primarily been to improve the productivity of online platform workers, so instantaneous translation and human interfaces using gestures and eye tracking are fairly widespread.

Small-scale use of additive manufacturing, often outside regulation in the grey economy, increases the numbers of flawed products on the market. Untrained operators are exposed to particulates and hazardous chemicals, for example in backstreet 3D printing operations.

Robotics and automation, commonly in manufacturing but also in the care industry, have improved OSH through reduced exposure of workers to hazardous environments and ergonomic hazards. However, there are also hazards associated with workers interacting with automated equipment, particularly collaborative robots, such as collisions, increased work pace and increased cognitive load. Improved electronic monitoring makes it possible to alert workers to the presence of hazardous substances.

Work-related stress is widespread as a result of extensive job and financial insecurity, poor work-life balance, the lack of predictability in the grey economy, work intensification in some jobs and task deprivation in others. Intrusive workplace electronic monitoring leads to stress and overwork. Some workers may also suffer from stress due to a lack of autonomy and job variation.

# 5 OSH implications

## 5.1 Overview

In this section, a more detailed discussion of the potential new and emerging OSH risks associated with ICT-ETs, as described in the scenarios, is presented.

First, it is clear that the trends and drivers of change indicate that by 2025 ICT-ETs will have changed the equipment, tools and technical systems that can be used to organise, manage and deliver products and/or services across most occupational sectors. Developments include continuing advances in automation that result in work processes that are increasingly complex, interconnected and autonomous in that they self-organise, self-learn and self-maintain. There is a clear trend towards the miniaturisation of ICT-ETs, which are also increasingly smart and connected to the internet (the Internet of Things). The trends and drivers of change indicate that these miniaturised ICT-ETs, along with bionics and exoskeletons, will be worn to enhance or monitor human performance, generating considerable amounts of data.

In addition, the trends and drivers of change indicate that by 2025 ICT-ETs such as 3D and 4D printing and bio-printing, autonomous vehicles (including drones), robotics (including collaborative robotics), AI, VR and AR, will increasingly be used for work purposes, and, moreover, that innovation in these technologies will continue. Developments in robotics, AI, autonomous systems and the IoT, among other technologies, will have a fundamental effect on the nature of work. Robots will increasingly become uncaged, mobile, dexterous, collaborative and increasingly intelligent, moving beyond their traditional strongholds to bring automation to previously inaccessible tasks. Even jobs not replaced by robots will change considerably as human workers will work in close proximity with, use and interact with a wide range of digital technologies. Highly developed sensors already make it possible for people and robots to work together in ever closer proximity, as machines are becoming able to register their users' behaviours with ever greater precision, thanks to technologies allowing better speech and image recognition, emotion detection and the registration of eye movements and gestures, and this trend will continue. Robots will also increasingly be equipped with self-optimising algorithms, enabling them to learn from their human colleagues. The use of robots can be expected in many different sectors and settings, such as in care, hospitality, agriculture, manufacturing, industry, transport, defence, customer-facing jobs such as services and administration, inspection bodies, etc. Most of the discussions around robotics are about job quantity, but they should also be about job quality, and OSH is an important aspect of that.

In addition, there will be ongoing development and innovation in human-machine interfaces that allow humans to interface with machines and one another remotely via ICT-ETs, in ways that are much more similar to how humans interact face to face, for example by voice, through gestures or visually. The first microchip implants in humans, using Near Field Communication technology, are reported to have removed the need to carry keys or credit cards, to buy train tickets or entrance to nightclubs, and employees of some companies have been microchipped to enable them to access buildings or security-restricted areas ([5]). The trends indicate that by 2025 direct brain-to-machine interfacing may have begun to emerge but will not be particularly widespread.

Many of the ICT-ETs used for work purposes in 2025 are expected to be increasingly customisable, interconnected via WiFi and to some extent interdependent. These will drive the need for better cyber-security, and new internet infrastructure, protocols and standards.

The extent of innovation in and adoption of the ICT-ETs described above and their impact on OSH will depend on the social, economic, environmental and political trends and drivers that exist between now and 2025. The horizon scanning undertaken during this foresight project (Task One of Work Package One (EU-OSHA, 2017a) along with the four alternative scenarios of the future that were developed (Section 5), have enabled a number of OSH challenges and opportunities that may emerge as ICT-ETs change to be identified; these relate to:

- the work equipment or tools used;
- how work is organised and managed;

([5]) https://en.wikipedia.org/wiki/Microchip_implant_(human); https://phys.org/news/2018-05-microchips-skin-technophile-swedes.html

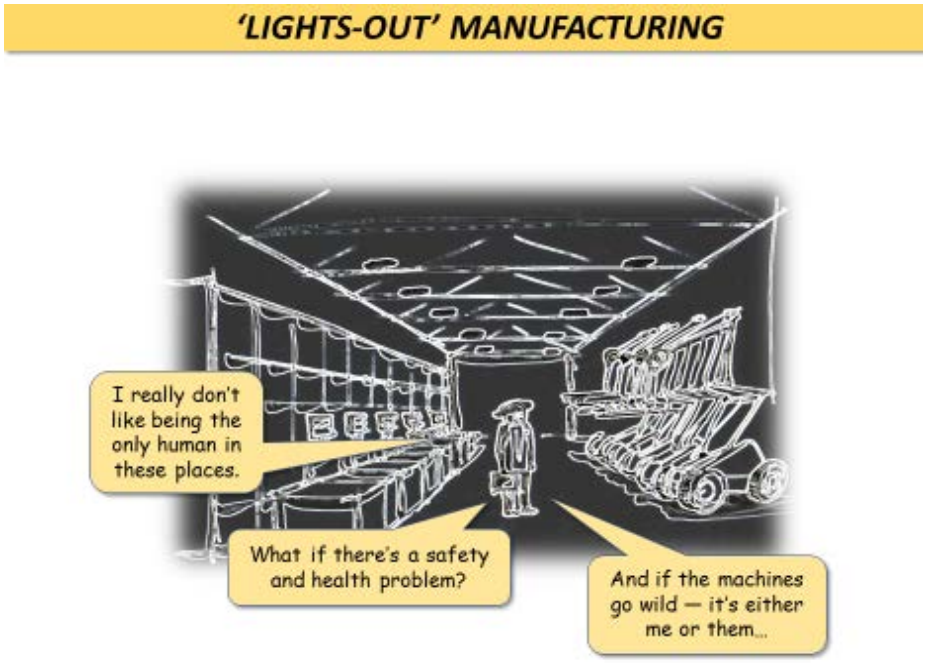
- employment status, hierarchies and relationships;
- the characteristics of the workforce;
- responsibilities for managing OSH;
- skills, knowledge and information requirements.

## 5.2 Work equipment and tools

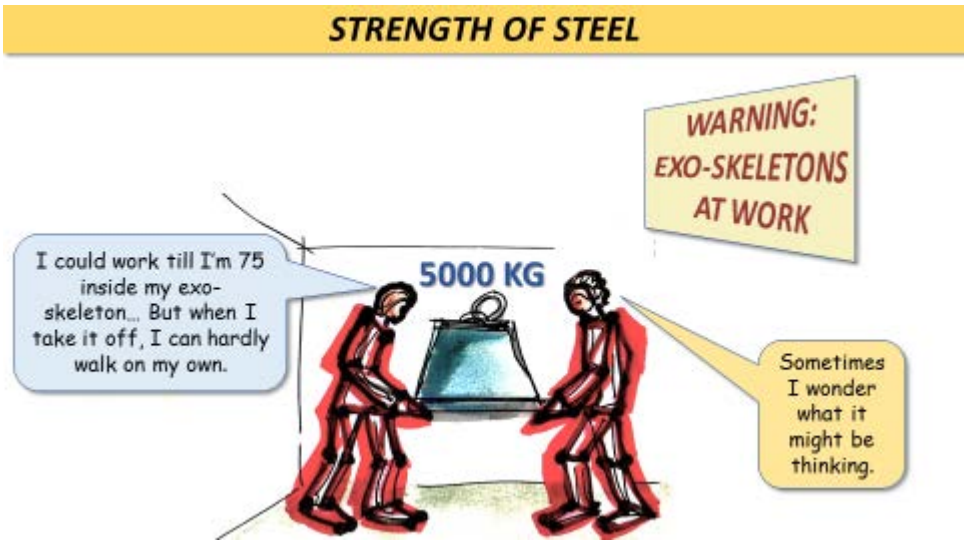
OSH challenges and opportunities directly related to the use of ICT-ETs as work equipment and tools include the following.

***Exposure to hazardous substances:*** ICT-ETs such as automation, robotics, remote interfaces and the use of VR for training purposes (Katwala, 2017a) can help to reduce workers' exposure to hazardous substances (if the challenges of accurately measuring one substance in the presence of others can be overcome), including biological agents such as allergens and pathogens. Precision agriculture, for example, uses autonomous robots to precisely deliver herbicides and pesticides only where they are needed. Monitoring of workers' exposure to toxic substances could be facilitated by the use of smart sensors incorporated into wearable devices. Affordable and increasing computer power, along with the availability of large datasets, could enable DNA profile sequencing to be used to screen out workers who are more susceptible to specific hazardous substances, although this could raise ethical concerns. Conversely, ICT-ETs such as 3D and 4D printing and bio-printing have the potential to increase exposure to a range of new substances the hazards of which are not yet fully understood. Moreover, these technologies are likely to be available to and used by micro-enterprises and (pseudo) self-employed who may not have adequate resources and skills to handle the associated substances safely. Workers in recycling could also be increasingly exposed to a wider range of more chemically complex materials, such as those used in 3D and 4D printing and bio-printing and/or new battery technologies developed to service the demand for mobile and wearable devices. Early adoption or trials of ways of interfacing via detection of brain signals could entail the close proximity of a range of plastics and metals to the scalp for extended periods of time, with the potential to cause an allergic reaction.

***Exposure to physical hazards:*** automation, robotics and autonomous vehicles or drones (Busick, 2016) can reduce the need for workers to work in hazardous environments such as confined spaces, to work at height, to be exposed to noise and vibration or to come into contact with moving machinery. They also offer the opportunity to hand off routine or repetitive tasks to fast, accurate and tireless machines. However, the same technologies could be a source of harm, through trapping, entanglement, impact, noise and vibration, should anyone work alongside them, for example in the case of collaborative robots (Knowledge at Work, 2017; Steijn, et al., 2016) or bionic exoskeletons. In the short term, accidents as a direct result of collisions of machines with people will increase over time because of the growing number of cobots, powered exoskeletons and autonomous vehicles in the work environment but should hopefully decrease in the longer term. With robots working alongside human workers, isolation as a safety measure will no longer be an option, and other safety approaches must be developed and implemented. A number of features can be used to make collaborative robots safer, such as sensors, vision systems, appropriate materials, soft, rounded edges, reduced speeds and force, and software tools (Boagey, 2016). Sensors on cobots should help to ensure physical safety for human workers; however, if the sensors fail, become dirty, or suffer from electrical interference or cyber-attack, safety systems may fail and there may be a risk of collision injuries to workers. Safety risks will also be caused by the equipment that robots use, and which could pose dangers to workers in the vicinity. Examples include lasers, radiation sources, welding electrodes and mechanical equipment (Steijn et al., 2016). Little government guidance or policy exists regarding the safe integration of robots into the workplace and this is a new field for OSH professionals.




***Manual handling:*** mobile autonomous robots or exoskeletons could assist workers with manual handling tasks and strenuous work. Such innovations could allow older workers to continue to do jobs that involve physical effort (Burgess, 2016) and create better access to work for disabled people. Traditionally, OSH in relation to robotics has been managed through the segregation of workers and robots. With robots working in close proximity to workers, new techniques will include sensors, vision systems, soft, rounded edges, and reduced speeds and force (Boagey, 2016). With closer and more innovative interaction, it could become increasingly important to understand how workers will behave (Stirling, 2015). Not only can collaborative robots take manual handling tasks away from workers, they can also offer a novel way of managing workers' manual handling risks, as electromyography sensors could be built into the clothing of people working alongside collaborative robots; the sensors would then be monitored by the robots so that they could warn wearers when they were in potentially harmful postures (Katwala, 2017a). In the case of exoskeletons, workers could get trapped and injured if they malfunction. Mobile autonomous robots and exoskeletons also need to be designed to ensure that they avoid or are physically stable enough to work on slopes or uneven ground, so that they don't cause injury to workers by falling over. An over-reliance on robots or exoskeletons for manual handling could have implications for workers' physical fitness, resulting, for example, in loss of muscle/bone density or joint flexibility. Exoskeletons could give workers a sense of invulnerability that could tempt them to take greater risks, owing to the additional strength given to the worker by the exoskeleton.

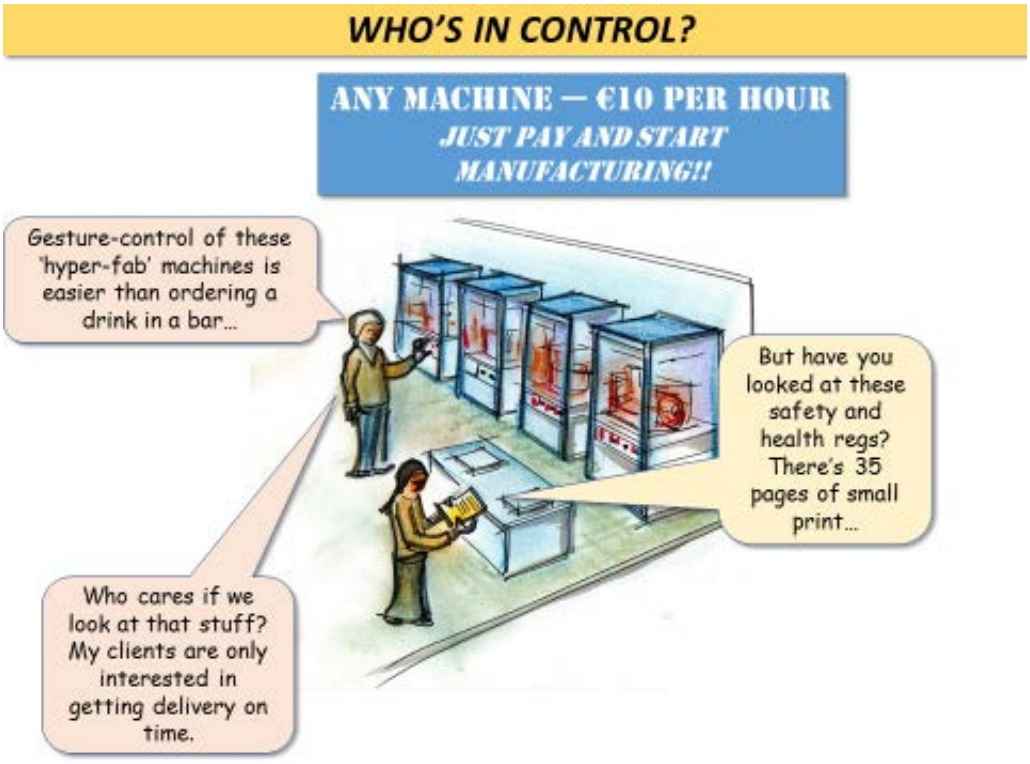


***Sedentary work: Sitting is the new smoking:*** ICT-ETs can make work more sedentary, as they are, in general, used while sitting (although sit-stand desks can be used). Work processes can be controlled, monitored and also increasingly maintained remotely, removing the physical activity associated with attending them in person. ICT-ETs also enable working from home (teleworking), which removes the physical activity, as well as the stress and the potential for road traffic accidents, associated with commuting. A more sedentary lifestyle can increase the risk of poor postures, cardiovascular disease, obesity, stroke and diabetes (IFA, 2017; Knowledge at Work, 2017; Wilmot et al., 2012), and may also increase anxiety (Teychenne et al., 2015). Increased time looking at a screen can also have significant effects on postural habits and cause MSDs, as well as having potential psychological effects such as internet addiction, which is estimated to affect between 1.5 % and 8.2 % of the US and European populations (Horton et al., 2018). However, digital technology can also help to reduce sedentary behaviour, for example through the use of wearables to alert users to the hazard and influence them to adopt healthy behaviour. New human-machine interfaces such as voice recognition, gesture control or eye tracking could also allow workers to use ICT-ETs while physically active or at least standing rather than sitting. The time saved by not having to commute could also be used for physical leisure activities.

***Workstation ergonomics:*** mobile ICT-ETs allow people to work anywhere, including at home, in public places and on transport. Hand-held mobile devices are not ergonomically suitable for use for long durations and can cause injury to the upper limbs, neck and back. Homes, public places or transport may not be ergonomically suitable for work purposes either. One study found that half of laptop users complain of impaired working conditions (IFA, 2017). It is not possible for employers to control such environments and it is also likely to be difficult to control how people work outside the office. Interfacing by gesture, voice or eye could improve ergonomics and also make work more accessible to a wider range of people with certain physical impairments or who do not have the ICT skills to use today's devices. However, more frequent use of gestures, the voice or the eyes for this purpose may result in overloading certain body parts, which could lead to new types of and/or an increase in health disorders such as eye and voice strain. Such interfaces may also involve the use of head- or handsets, potentially leading to MSDs.

***Risk intensification:*** automation, while offering OSH benefits to many workers by removing them from exposure to hazardous environments, could also leave to workers only very repetitive tasks, with the robot determining the rate at which they are carried out, or the more difficult and/or dangerous tasks, and reduce the scope for task rotation and variety. For example, what is left could be a limited range of manual handling tasks requiring high dexterity, which could lead to an increased risk of repetitive strain injury. There is a trend towards the extreme specialisation of tasks, for example in warehousing, transport and distribution functions in the retail sector. Tasks that are more difficult to automate also include fault-finding or unplanned maintenance activities, which tend to be more hazardous than normal operations (HSE, no date).

***Control commands lost in transmission:*** human-machine interfaces, such as those based on gesture, voice, eye tracking or brain signals, could be misinterpreted by the work equipment or process under control. This could be caused by low signal strength or electromagnetic or malicious interference with the signal. Misinterpretation could also occur because of the use of dialects or the ambiguity of human language. Incorrect commands could be sent if someone was stressed or distracted (Abdlkader et al., 2015). If work equipment and processes are controlled remotely, there is also the potential for commands to be accidentally sent to the wrong equipment or process. Gesture, voice, eye tracking or brain signal control is more immediate (e.g. there is no pause to hit enter on a keyboard). It could, therefore, be important for safety-critical commands to require a means of giving unambiguous confirmation before they are executed. Noise levels in working environments, public places and transport could also increase owing to increasing use of voice-controlled interfaces.

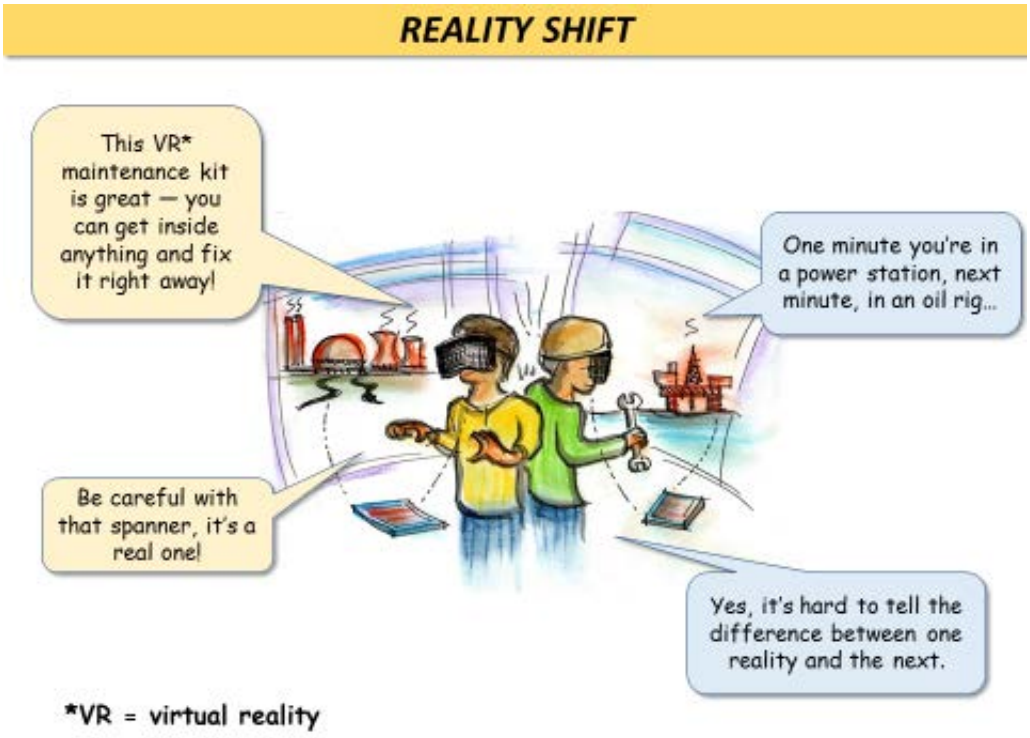



***Human-machine interaction and cognitive demands:*** real-time, interactive, direct and immersive human-machine interfaces could make it very difficult for workers to be able to pause or relax. If people work collaboratively with robots, they may be placed under pressure to perform at the speed of the robot. This could result in workers trying to meet very high efficiency demands placed on them by a robot that does not understand that humans cannot work at maximum efficiency all the time. ICT-ETs also enable some work processes to be automated such that some operators' roles will become supervisory, with only occasional intervention; operators are, therefore, likely to be required to oversee a number of work processes in several different locations, which could further increase cognitive demand. Intensive periods of continuous high cognitive demand placed on workers have the potential for negative impacts on OSH, particularly on mental health. Adaptive automation refers to the concept of software monitoring people who work with robots to adapt the speed of the process and prevent overloading (Steijn et al., 2016). This means that workers remain in control of the work process and workload, and it should also lead to greater acceptance of automation in the workplace.

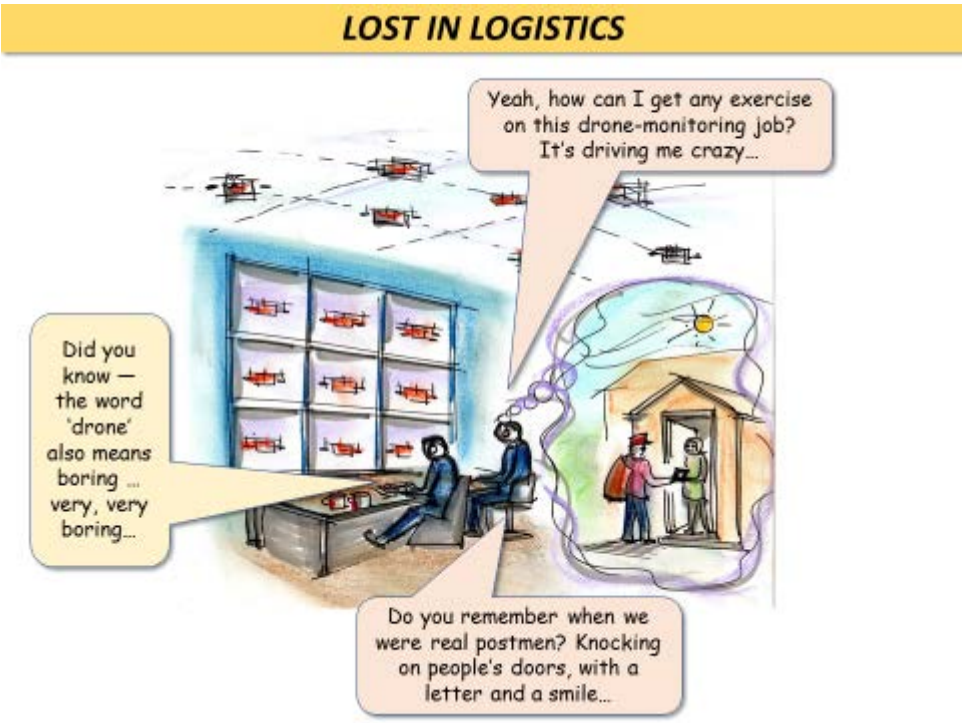
***Unforeseen situations:*** when designing robots, even if every effort is made to plan for all possible scenarios, it is impossible to foresee all situations. Ultimately, how safe it is depends on how the robot is used (it might be used incorrectly), and risks could be driven by spontaneous and unforeseen actions by people, unexpected situations arising, software interacting with other software in ways previously unanticipated or a particular scenario arising that was simply not considered (Steijn et al., 2016). Incidents also — or especially — occur outside of normal operation, such as during the installation, testing or maintenance of robots. This underlines the importance of considering the entire life cycle of robots.

***Lack of transparency of algorithms:*** a lack of transparency about how AI is analysing data and learning could lead to it behaving in unpredictable and unsafe ways. In the case of deep learning algorithms, for example, there is no way to identify which factors the deep learning program uses to reach its conclusion (Pega and Marketforce, no date). If workers do not understand how systems are working, they may find it difficult to interact or interface with them correctly, recognise when they go wrong and know how to respond if they do or in case of system failure. Workers may also suffer from stress and anxiety if they do not know what is happening, what data are being collected and for what purposes (see also 'Digitalised management methods, including algorithmic management' in Section 6.3).

***Situational awareness:*** workers who use ICT-ETs to inform them about hazards could become less able to spot them on their own or check the information should the systems fail. This could lead to a decrease in situational awareness in general. A decrease in situational awareness can also arise when using VR devices, because of motion sickness and/or a loss of awareness of the user's actual surroundings during and even for some time after use (Hiesboeck, 2016). AR devices overlay reality with computer-generated information. The overlaid information could make it less easy to see OSH-critical situational information because of distraction, disorientation or information overload. However, AR could also improve situational awareness by providing supplementary contextual information, for example on the presence of hidden hazards such as asbestos, electricity cables and gas pipelines. AR can incorporate instructions, which could reduce human error, as workers would not need to refer to separate guidance while their hands were needed for maintenance activity. However, the reliability of AR is dependent on maintaining access to the relevant information sources, the quality of the information and whether or not it is up to date.

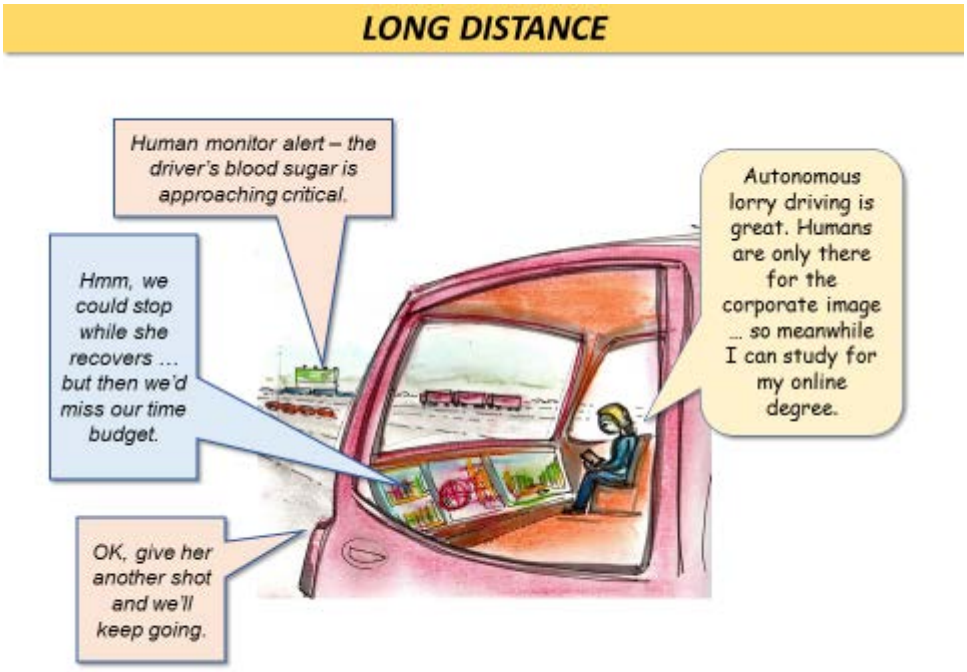



***Task deprivation:*** ICT-ETs enable work processes to be controlled, monitored and also increasingly maintained remotely. Jobs could, as a result, lose content and variety and become less satisfying. In addition, as equipment becomes smarter and more reliable, workers could be monitoring processes that rarely go wrong, resulting in boredom and loss of concentration (cognitive underload).




***Malfunction caused by sabotage:*** if perception, understanding and trust in ICT-ETs are poor, workers may avoid using them or even act maliciously to try to confuse or defeat them, and sabotage will become more common. Workers' perception, understanding and trust will influence how they interact with ICT-ETs. Workers should be consulted and involved in strategies for deploying ICT-ETs in the workplace to ensure better OSH, as well as to increase acceptance and reduce sabotage.

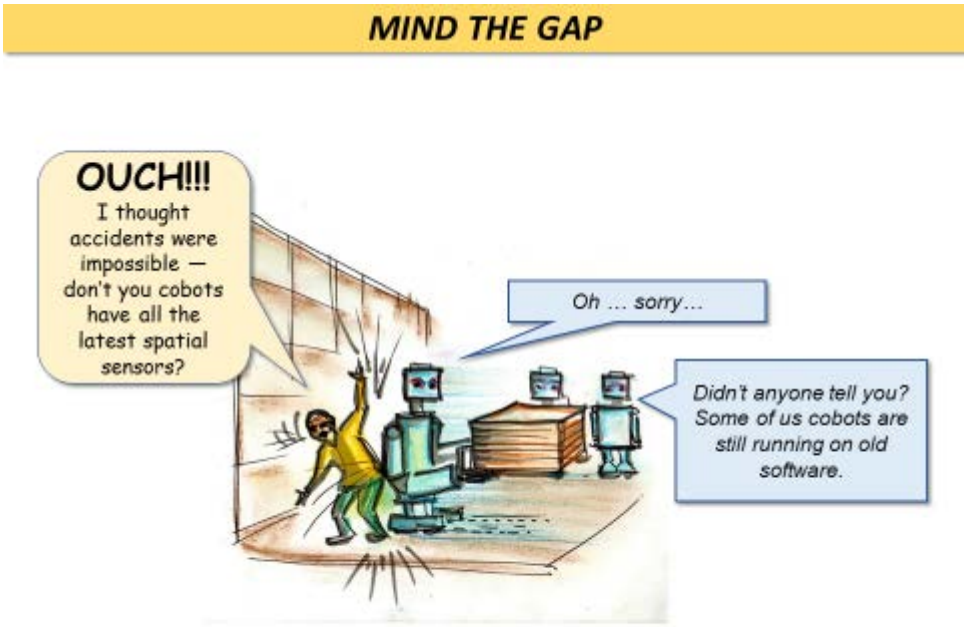
***Adaptive, socially and emotionally intelligent robotics:*** some experts believe that the greatest industrial benefits will be achieved if the functional and analytical abilities of robotics and AI complement the skills of the workers who interact with them (Khan, 2017). At present, work processes are often designed according to what is technically possible, with customer demand being the guiding factor in what the autonomous robots are able to do and what they have to do. A better method would be to implement a user/worker-centred design approach involving those who will actually be using the technologies (the workers) during their development in order to use their knowledge of work processes to identify the tasks best suited for automation/robots/AI and to design digital work processes from the point of view of workers being assisted by the technology rather than the other way around. This would also contribute to preventing cognitive issues (underload and overload) by making it possible to designing robots and introducing them into the workplace with the goal, among others, of making or keeping the work interesting and challenging. It is also important to increase workers' acceptance of robots being introduced into the workplace, thus minimising sabotage and therefore the risk of accidents. In this regard, the development of adaptive and socially and emotionally intelligent robotics should be mentioned. Adaptive automation uses software to monitor people working with robots to adapt the speed of the process and to prevent overloading. This could mean that workers need to interact constantly with such systems and thus remain in control of the work process and workload. If adaptive automation systems are designed to take account of the social and cognitive load aspects of work they could prevent work-related stress and ensure that automation was better accepted by workers.




***Customisation:*** ICT-ETs often allow users to personalise them to a considerable extent. This can make them more user friendly for the person who has customised them, but less so for someone else. If a worker has to use a device customised by another, they may, for various reasons, not re-customise it. This could lead to stress, ergonomic-related harm or human error. Customisation culture could also lead to work equipment being used for a purpose for which it was not designed. The rapid reconfiguration of work processes in response to demands for and expectations about customisation from consumers may mean that the risk profile of a factory changes frequently. This could make it difficult to standardise procedures, risk assessments and other aspects of the management of OSH.

***Pace of technological change:*** if the pace of change to work equipment is high, ICT-ETs may be replaced on failure rather than mended. This could reduce maintenance-related accidents. However, this could also increase the mix of technologies present in the workplace and create integration-related OSH issues. Pressure to bring a new design to market quickly, owing to consumer demand or competition, could increase the risk of design flaws not being found before work equipment is put into service, so that it could fail in unpredictable and hazardous ways. A high pace of technological change could cause mental health problems or exclusion from good-quality work for those unable to cope with constant change or 'newness' (sometimes referred to as 'technostress') (Suh and Lee, 2017). If workers' skills are unable to keep pace with change, this could have OSH consequences as a result of human error. If the rate of technological change is high, OSH research and regulation may also struggle to keep up.

***Mix of old and new:*** there is the potential for OSH risks during the transition from old to new technology when both are in service, particularly when the new needs to be integrated with the old and at the interfaces between the two. Infrastructure designed for old technology may not be suitable for new technology and could as a result introduce unforeseen OSH risks. If workers need to interact differently with old and new technology they may make incorrect and unsafe assumptions about how the technology will behave. There is also the potential for confusion and accidental use of the wrong procedures if old and new versions are both current. Clear communication will, therefore, be essential.




***Big data for better OSH:*** more powerful computing enables machine learning and AI to sort and analyse, at high speeds, the large amount of data collected by monitoring of increasingly complex systems such as smart energy grids (Steck and Venables, 2017). This has the potential to provide better insight into OSH problems, to support better OSH decisions, and to allow more timely and effective interventions, even giving advance warning of or predicting OSH problems before their occur. It can even allow businesses to more easily demonstrate compliance with OSH standards and regulation, and labour inspectorates to more easily investigate breaches.

***Smart PPE:*** mobile miniaturised monitoring devices embedded into PPE could measure real-time exposure to hazardous substances (if the challenges of accurately measuring one substance in the presence of others can be overcome), noise or vibration. New types of data analytics that enable real-time analysis based on big data flows can make autonomous decisions (Chui et al., 2013; Flaig, 2017). This could be used to provide early warning of harmful levels of exposure (Knowledge at Work, 2017). Smart PPE could also monitor posture, activity levels or a range of biological vital signs (Knowledge at Work, 2017) that, when processed by computer algorithms, could identify early signs of health problems, fatigue or stress. Real-time tailored advice could then be provided to influence worker behaviour to improve safety and health. Collated information could also be used by organisations to spot where OSH interventions at an organisational level were required. However, effective strategies and systems are likely to be needed to allow the handling of the large quantity of sensitive personal data that could be generated and also to decide what to keep and use for what purposes, how and by whom to use it, and what to discard. Malfunction could cause direct or indirect (through incorrect data or advice) injury or ill health.

***Integration and interconnectivity*** could result in undesirable and poorly understood OSH consequences. Cascade failure could, for example, occur because of high levels of interconnectedness and inter-reliance of ICT-ETs. All this makes the reliability and safety of AI and machine learning difficult to evaluate. The short-term impact of AI depends on who controls it. In the longer term, the impact depends on the extend to which it can be controlled.

***Transport of raw materials:*** ICT-ETs could allow advanced automated manufacturing processes, including 3D and 4D printing, to be accessible to micro and small enterprises at a local level or to local outlets of larger companies. This could result in more raw materials and less finished products being transported. Some raw materials can contain hazardous substances at more concentrated levels in a more easily dispersible state. This could also mean smaller and more frequent deliveries to smaller premises that may not be suited to the use of manual handling aids. Goods may, therefore, have to be moved by hand by workers whose main job may be something very different and even sedentary.

***Counterfeit parts*** could be more widely available owing to the increasing ease of use and availability of 3D printers. This could cause hazardous malfunction of work equipment after maintenance or repair.

***Exposure to electromagnetic fields*** (EMFs) could increase both in terms of duration and intensity if 5G WiFi networks and contactless charging of mobile ICT-ETs become more widespread. New biometric security devices, such as those that uses the size and shape of the user's heart as a unique identifier, could also expose people to additional EMFs, although developers point out that their heart-shape device emits less than 1 % of the EMFs emitted by smartphones (Katwala, 2017b). Direct brain interfaces could also expose workers to strong EMFs. By 2020, the number of devices connected to the IoT is expected to rise to over 20 billion (Gartner, 2017), and they could be susceptible to electromagnetic interference, inadvertent or malicious.

## 5.3 Organisation and management of work

OSH challenges and opportunities relating to developments in ICT-ETs and how ICT-ETs are used to change how work is organised and managed include the following.

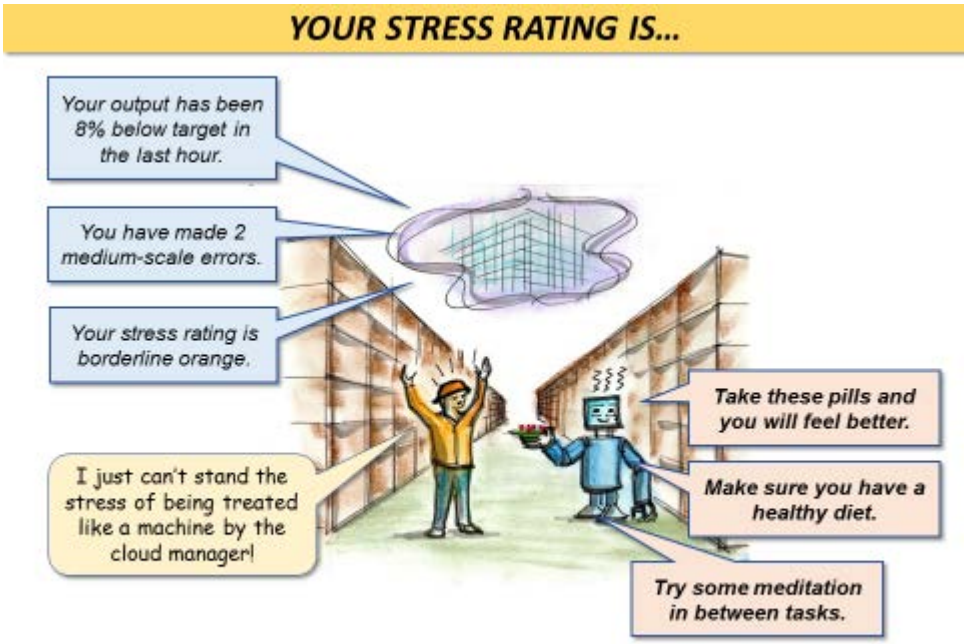
***Flexibility, availability and blurring of work/private life boundaries:*** ICT-ETs can allow people to work any time and anywhere, including from home. This could lead to a blurring between people's work and private life in terms of both their activities and their safety and health (Mandl et al., 2015; Messenger et al., 2017). The loss of the commute to work could make it difficult for workers to transition from private to work life at the beginning of the working day and back again at the end, which could have a negative impact on mental well-being (Redmond and Mokhtarian, 2001). ICT-ETs' ability to enable working at any time could lead to a real or perceived need to be available all day every day (24/7), which could lead to stress (Unum, 2014). For example, people may need to work with colleagues in a different time zone, creating the need to work at unsociable times of the day. There are concerns that people may suffer from addiction to the use of mobiles, laptops or wearables — also referred to as digital addiction, separation anxiety, fear-of-missing-out syndrome and nomophobia (Elmore, 2014) — such that the user suffers from severe anxiety if separated from the device or if it stops working, and this could increase as the use of such devices becomes more widespread and their features more advanced and necessary for work or life in general. Availability 24/7 could have similar OSH impacts to shift working, such as cancer, particularly when people work nights (IARC, 2007), diabetes and cardiovascular disease (Cordis, 2017b). Some workers may consider being seen to be available 24/7 a sign of being successful but suffer from the abovementioned medical problems, stress and/or burnout as a result. Sleeping disorders can also be caused by the low-intensity light emitted from ICT-ETs in bedrooms or when using mobile devices just before sleep (Volpi, 2012). This can cause various health problems, including obesity, heart disease and diabetes, as well as stress (Horton et al., 2018; WHO, 2004) and indirect OSH issues due to cognitive impairment.

***Digitalised management methods, including algorithmic management:*** work is becoming increasingly coordinated and overseen by computer algorithms, and in the future management of workers could rely heavily on AI. Digitalised management methods are characterised by, among other things, the use of big data and algorithmic distribution of work; the use of people analytics, such as digitalised profiling, in HR management; tracking wellness and productivity using sensory and other monitoring devices, as well as tone and sentiment analysis; and using the data accumulated to make human resource decisions on, for example, work and workplace distribution, performance appraisals or even hiring and firing. As a result, workers can lose control over work content, pace and scheduling, and the way they do their work (Moore, 2018). This is associated with work-related stress, poor health and well-being, lower productivity and increased sickness absence (HSE, 2017). Such algorithms also tend to collect productivity data that can be used to reward, penalise or even exclude workers. This could drive unsafe OSH behaviours in workers where OSH and productivity are in opposition. Workers may not feel able to take breaks when they want to or interact socially at work, which could have a negative impact on their health. If workers are informed of how their performance compares with that of others — or possibly with that of machines — it could cause performance pressure, anxiety or low self-esteem. According to a survey of senior executives in a number of sectors and industries around the world, while 88 % say they would be comfortable with the idea of working alongside intelligent machines, and 91 % with the idea of managing them, as many as 4 out of 5 would not be comfortable with an intelligent machine managing them (Pega and Marketforce, no date). However, new types of data analytics/intelligent algorithms (machine learning) combined with access to

large datasets could also enable a better understanding of OSH risks in general (Flaig, 2017). This understanding could be used by intelligent algorithms to provide more effective real-time oversight of OSH by the algorithmic manager.

***Performance pressure:*** the use of ICT-ETs could cause a mismatch between workers' physical and/or cognitive capabilities and work demands. This could happen, for example, when working alongside collaborative robots, for AI bosses or with automated systems that have been designed to maximise the productivity benefits of such technologies without adequately considering the impact on human workers. It can also happen when, for example, online work platforms reward speed; when there is uncertainty about when the next piece of work will be available (so workers accept a request when busy with others, creating demand conflicts); or when failure to accept work is penalised (Mandl et al., 2015). When work is overseen by AI, it can contain embedded continuous improvement algorithms that are referred to by some as the 'digital whip'. According to a survey of senior executives in a number of sectors and industries around the world, more than 7 out of 10 think it will be common to use AI to evaluate workers' performance and set rewards in the next 10 years (Pega and Marketforce, no date).

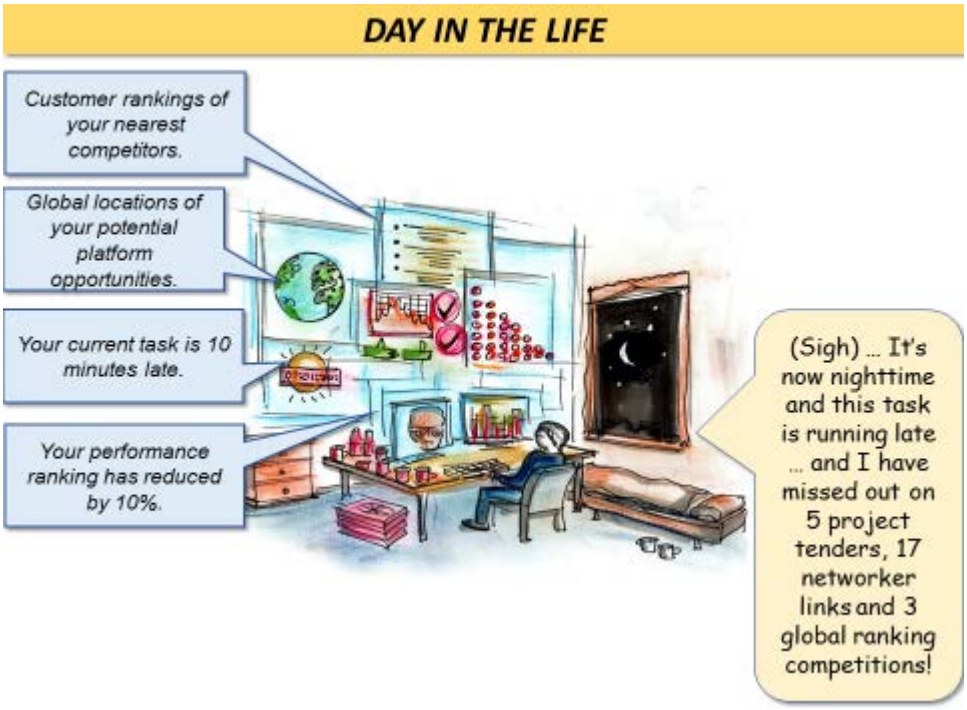
***Constant oversight:*** mobile, wearable or embedded ICT monitoring devices, used by AI or human managers, can have a negative impact on well-being if workers feel that they have to conform to an expected behaviour that may not come naturally to them; they have to meet challenging performance targets; or they are unable to interact socially or take breaks when they want to. Constant oversight can also cause stress and anxiety, particularly if combined with a lack of control (real or perceived) of work pace and schedule (HSE, 2017) or with job insecurity, and, moreover, when there is no information on/understanding of what data are collected, how they are used and for what purpose. There may also be issues related to data protection/privacy; mis-interpretation of data, when data are compared without looking at the context or qualitative data; and the mis-use of data to discriminate against some workers. On the other hand, ICT monitoring can also reduce anxiety, for example where online platform workers use it as evidence of time spent completing tasks in order to get paid fairly.




***Privacy invasion:*** ICT-ETs have the potential to invade workers' privacy in a number of different ways. Online platform workers, for example, may have to provide personal information without a clear guarantee of confidentiality (Mandl et al., 2015). ICT-ETs that are mobile, wearable and/or embedded in the bodies of workers could be used to constantly monitor them for a variety of reasons including productivity, appropriate behaviour, alertness and exposure to OSH risks. This could include monitoring of exact location, what they are doing, vital signs and indicators of mental well-being. Employers may encourage or require the devices

to be worn also during leisure time, to measure sleep patterns and amount of exercise, on the basis of a possible link to productivity and safe OSH behaviours. Direct brain-to-machine interfaces may collect lots of additional information about personal thoughts as well as control signals (Abdlkader et al., 2015). This could cause perceived or real invasion of privacy, and a feeling of loss of control over one´s own data, leading to anxiety and stress (Suh and Lee, 2017).

***Ethics of AI decision-making:*** the more people work with AI machines and robots able to take more autonomous decisions, the more important the question of ethics will be. Do such systems always make better choices and decisions than humans? Are they able to make ethical decisions, and, if so, who and what should determine what these decisions should be based on? For example, should a robot put a single worker in danger to maintain the overall safety of a plant? In many cases, we do not even know how a person would react in these situations, so how can a machine be pre-programmed to make such decisions? The next question is whether or not a worker can, will or should accept decisions and instructions from an AI machine even when he or she disagrees with the machine (ETUI, 2017; Stein et al., 2016). The transparency and ethics of AI algorithms', machines' and robots' decisions will have an impact on workers' trust in and acceptance of such systems, as well as on workers' levels of stress and anxiety and other aspects of their mental health.




***Cyber-security:*** the trend towards work processes and devices being controlled by and communicating with one another via the internet (or GPS technology, IoT systems, wireless networks, central databases, etc.) means that there is the potential for hackers to take control of them. This could compromise OSH, as hackers could attack critical infrastructure; take control of devices so that they behave in unexpected or hazardous ways; deny access to essential data; and/or steal or corrupt personal or OSH-sensitive/critical data. To give some examples, researchers from the security company Symantec have already found evidence of a sustained hacking campaign against electricity grids in a few countries (Ng, 2017); in Germany, a steel plant was hacked and the attackers managed to shut down the furnace; in the US, as many as 90-100 % of companies' IT security systems have already been attacked; and in 2017 the US Food and Drug Administration (FDA) recalled approximately 465,000 pacemakers that were vulnerable to hacking as the devices can be remotely "hacked" to increase activity or reduce battery life, potentially endangering patients (Hamlyn-Harris, 2017). The trend towards workers using their own ICT devices for work or bringing their own devices to work, known as bring your own device (BYOD), could make cyber-security more difficult because of the range of devices, which may not be secure, that are connected to work networks. The increasing use of social media at work (for work or personal purposes) could also

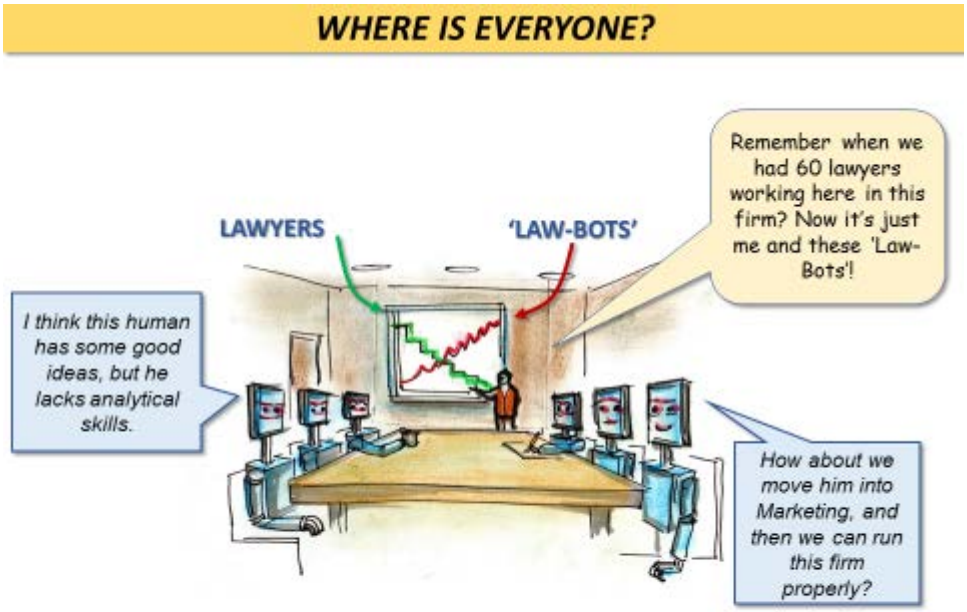
cause a cyber-security risk, because social media is regularly hacked and could provide a route into organisations' networks. Quantum computing, which could begin widely available by 2025, could in theory break any of today's computer security encryption. Researchers are therefore working on perfecting new technology to protect against this possibility (Folger, 2016). In Europe, the CORDIS project is an ongoing EU project aimed at improving the prevention and detection of cyber-attacks on utilities including water and energy supplies (CORDIS, 2017).Some OSH institutes have started to recruit experts in cyber-security and OSH (e.g. the German IFA).

## 5.4 Business structures, hierarchies and relationships

OSH challenges and opportunities related to the impact of the use of ICT-ETs on employment status, hierarchies and relationships at work include the following.

***Work casualization/online work platforms:*** online platforms create new business models by matching demand and supply for labour and facilitate labour market access for vulnerable groups. Online platform work comprises a variety of working arrangements — generally 'atypical' in some way — different types of jobs and many forms of non-standard employment, from high-skilled work carried out online to service work carried out in people's homes or other premises and managed via platforms. Consequently, working conditions also vary significantly. All the risks of specific work activities themselves are present in online platform work, but they are likely to be aggravated by the specific features of online platform work/workers: lower average age; lower training levels; working in a variety of private settings; virtualisation of relationships and loss of peer support; loss of the protective effect of a common workplace; work requests issued at short notice (hours rather than days) with penalties in terms of future work opportunities for not being available; time pressure and rapid pace of work; fragmentation of jobs into tasks with narrowed job content; loss of job control; continuous real-time evaluation and performance rating, associated with performance pressure and work intensification; increased competition as online the labour market becomes global and accessible to more workers; irregular hours; insecure income; payment by tasks carried out but not for the time spent looking for work, which can extend the working day; blurred boundaries between work and private life; a lack of adequate HR support; unclear employment status; no social entitlements such as sick pay and holiday pay; poor worker representation; and unclear responsibilities for OSH. Online work platforms are, in general, currently not obliged to provide regular work, but have the flexibility of calling workers in on demand. In some cases, online platform work offers desired flexibility in terms of working time and place of work (Suh and Lee, 2017), but in many cases it is associated with forced flexibility. The mental health of those in poor-quality jobs has been found to be equivalent to or worse than that of those who are unemployed (Chandola, 2017). It has also been found that workers in non-standard forms of employment have higher injury rates (ILO, 2016). The online platform economy creates new challenges for labour protection and OSH management, and there are key questions around responsibility and regulating OSH (EU-OSHA, 2017b). So far, the phenomenon of online platform work is limited but it is a fast-expanding area, and the effects on the labour market and labour protection are disproportionately disruptive.

***Autonomous workers:*** the use of ICT-ET could enable flatter organisational structures with fewer middle-management posts (IFA, 2017). This could mean that workers have more autonomy over how they do their jobs (Mandl et al., 2015; Messenger et al., 2017) and in some cases also where and when. This could give workers more control over their workload and work patterns, thereby reducing work-related stress and improve workers' well-being (HSE, 2017). However, the loss of supervision by and support from middle management could also have a negative impact on OSH outcomes because, generally, middle managers have responsibilities for workloads, schedules, worker behaviour and well-being. The benefits of oversight would be lost, as might OSH expertise and tacit knowledge. Workers might not have the necessary skills to be able to manage their workloads in a safe and healthy way. Moreover, a loss of peer support and general social interaction at work could have a negative impact on workers' mental health and well-being. There are also psychosocial issues associated with the loss of status and financial expectations of those who were, or aspired to be, middle managers.




***Lone working:*** lone working could increase as human peers are replaced by ICT-ETs. Dehumanisation of work and relationships will make jobs less satisfying as the human/social aspects are lost and tasks become less varied. Doctors and nurses will lose contact with patients with the introduction of care robots, diagnostic robots and surgery robots. Even in the service and public sectors, service robots are expected to take over tasks involving contact with customers. As ICT-ETs enable many jobs to be done remotely, people could increasingly work alone without anyone knowing or being able to assist when they have an accident or suffer the sudden onset of a serious health problem. Lone workers in public places and delivery drivers could also be vulnerable to physical violence or verbal abuse from third parties. However, ICT-ETs can be used to reduce risk, for example wearable devices can monitor vital signs and GPS location and be used to communicate with the emergency services if needed.

***Loss of social skills and cyber-bullying:*** increasing dependence on social media and the internet for work purposes could increase the amount of cyber-bulling by competitors, peers, stakeholders or cyber-trolls. Virtual communication does not match the richness of face-to-face communication, and a lack of social contact may lead to less well-developed social skills (e.g. team-working skills and tolerance), leading to an increasingly negative communication tone that may include hostile language, and an increasing sense of depersonalisation that could feel like bullying. Innovative, more immersive, interfaces may counteract this effect at least to some extent.

***Collaborative employment*** refers to freelancers, the self-employed or micro-enterprises working together to overcome limitations of size and professional isolation, for example by jointly employing workers (Mandl et al., 2015). ICT-ETs can be used to facilitate this. This kind of employment can improve the well-being of individual workers by providing full-time employment where one organisation alone would have been able to offer only part-time or occasional work. It can also allow diversification, improve social interaction and provide support networks.

***New collective bargaining models:*** negotiations on pay and conditions, the organisation of worker representation, and participation in the design of workplaces, activities and equipment have traditionally been done through trade unions. Trade unions have, in general, tended to focus on one or a few closely related sectors and to have representatives based at workplace locations. New business models and structures, enabled by ICT-ETs, mean that workers may work across sectors, work for several employers, not be based at specific locations and/or be (pseudo) self-employed. This could lead to a loss of trade union membership and as a consequence reduced collective bargaining powers with a potentially detrimental impact on OSH (ILO, 2016). However, ICT-ETs could also facilitate new collective bargaining structures

and models that better reflect and work alongside the new business ones. One example is the Independent Drivers' Guild, which is an association for self-employed New York City drivers (estimated to total around 35,000 drivers in May 2016), formed to represent drivers in meetings, including when drivers appeal against decisions to penalise them (Warhurst et al., 2017).

## 5.5 Workforce characteristics

OSH challenges and opportunities relating to the impact of the use of ICT-ETs on the characteristics of the workforce include the following.

***Dispersed workforce:*** ICT-ETs allow an increasing range of work to be done anywhere and any time, so work processes can be decentralised, geographically dispersing the workforce. This can lead to the loss of the office or factory environment on which OSH management, oversight and regulation has traditionally been based and create barriers to good-quality worker involvement and peer support. There is also the potential for a dispersed workforce to experience professional and social isolation (Suh and Lee, 2017), as well as being exposed to the risks associated with lone working (see 'Lone working' in Section 6.4). Loneliness is associated with a greater risk of cardiovascular disease, dementia, depression and anxiety, as well as impairing reasoning and decision-making, which could have implications for OSH (Murthy, 2017).

***Diverse workforce:*** ICT-ETs give access to work irrespective of geographical location, cultural background, physical disability and age group. This could lead to a very diverse workforce with a wide range of different OSH needs. A diverse workforce may also have different social skills, training needs and preferences in terms of their approach to tasks, including what ICT-ETs they use. For example, different generations are likely to have preferences based on the type of ICT-ETs that were prevalent in their formative years. This could make OSH management more difficult. Businesses may need to take a flexible approach to how different generations and workers´groups do the work. However, ICT-ETs could also help by providing instant translation for voice-activated interfacing with machines or other workers remotely and use AI to incorporate cultural context. This could allow the fundamental principles of OSH practices to be better standardised in multinational organisations, which could have OSH benefits.

***Multidisciplinary working:*** ICT-ETs can give businesses and organisations easier access to workers from a range of different disciplines. The different working cultures that can exist in different disciplines along with the different protocols and terminology that are used could hinder a generic approach to OSH and the transfer of OSH information. However, a multidisciplinary approach including distributive problem solving (Chui et al., 2013), which is facilitated by ICT-ETs, could be beneficial to solving OSH problems and/or improving the management of OSH.

***Extended working life:*** ICT-ETs could enable workers to retire at a much older age as the use of autonomous vehicles, bionics and exoskeletons, or on-line platform work enable an ageing population to continue to work. This could mean that they may be exposed to work-related risks for much longer. This could increase the probability of their developing the type of health problems that are caused by cumulative exposure to these types of hazards. In addition, although older workers tend to have fewer accidents, when they do have accidents, their injuries are often more severe (CCOHS, 2012).

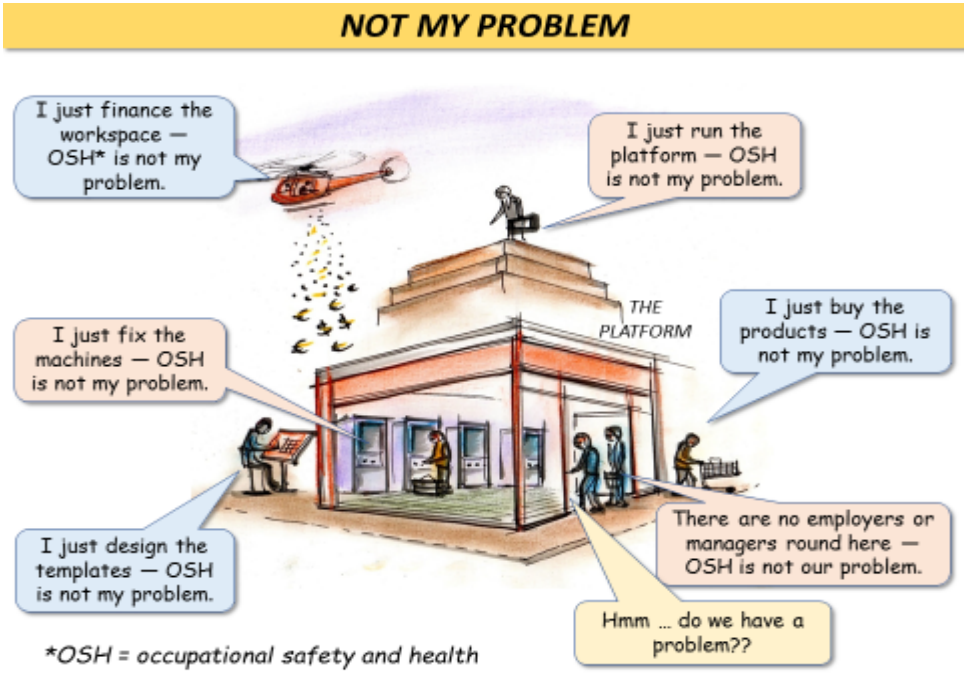
***New workers:*** Online platforms can enable workers to frequently change their jobs and the type of jobs they do as such platforms give access to a wide variety of types of work - and may not have mechanisms to check whether workers have the appropriate skills for each job. There could, therefore, at any one time be many more workers who are new to the job and who are statistically more likely to have accidents (Trotto, 2016). However, this may be less of a problem when each piece of work is very similar.

***Inequality:*** ICT-ETs have the potential to drive increased inequalities (EPRS, 2017; Nield, 2017) and the workforce in terms of pay and conditions (Evans-Pughe, 2017). Digital entrepreneurs can use ICT-ETs to set up and quickly expand online businesses with low capital outlay. At the same time, ICT-ETs can offer low-skilled workers easier access to work, creating competition for work that could, if unregulated, drive down pay. This could lead to the rise of an online grey economy of unregistered workers who fall outside regulation. All of this could lead to social polarisation (Degryse, 2016).

## 5.6 Responsibilities for OSH

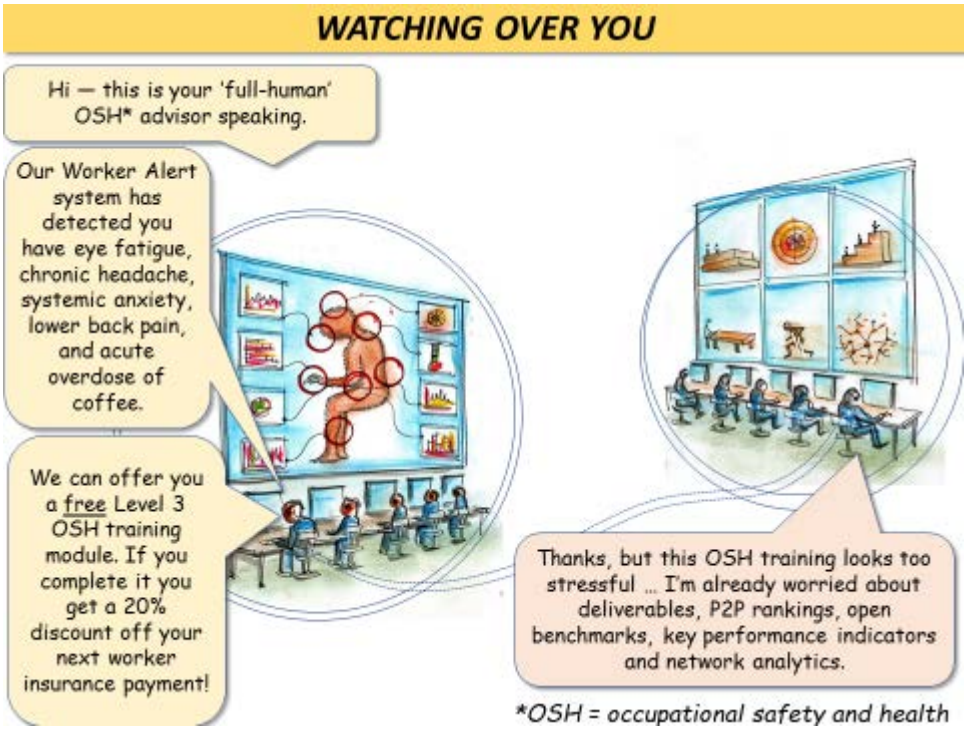
OSH challenges and opportunities related to how the use of ICT-ETs could change responsibilities for OSH and how they are discharged include the following.

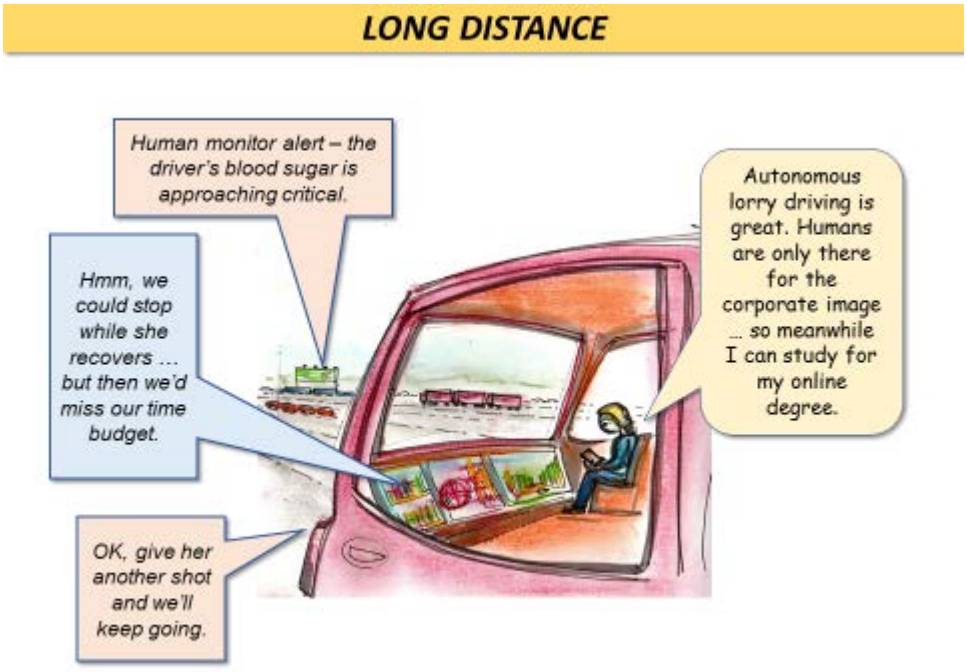
***Online platform economy:*** on the one hand, online platforms provide a regulatory opportunity to address undeclared work, but, on the other, they also present regulatory challenges as they are a 'moving target' and it is difficult to fit the activities into pre-existing regulatory categories. Specific features of online platforms, such as triangularity of the parties involved, temporariness, informality, autonomy and mobility, make it more difficult to establish an employment relationship. The owners of the platforms tend not to consider themselves employers (and neither do the demand-side users) but to treat workers as self-employed and therefore responsible for their own OSH. However, there is some debate about whether workers dependent on online work platforms are truly self-employed (EU-OSHA, 2017b). Online work platforms operate in diverse ways and exercise different levels of control (RSA, 2017). Some online work platforms set rates and exert considerable behavioural control, for example through penalties for workers who fail to comply with certain standards or targets, which some feel is equivalent to acting as an employer (Warhurst et al., 2017). As the application of current OSH regulations requires an employment relationship, the question is to what extent does/should employment law, including OSH law, apply to platform work. Labour inspection is also challenged by the blurred role and responsibilities of the employer in relation to the workers, by the lack of clarity on who is responsible for risk management, and by work being done any time and anywhere. As many platforms are international, a level playing field may need to be ensured (EU-OSHA, 2017c).




***Continuity of OSH surveillance and associated records:*** ICT-ETs could change the nature of work so that workers frequently change jobs and/or have more than one job. When combined with a lack of clarity about OSH responsibilities, this could cause a loss of continuity of OSH surveillance or records. However, ICT-ETs could also facilitate new ways to organise OSH surveillance and keep records that better reflect new business models and structures. The IoT, sensors in surrounding devices and robots, and wearable monitoring devices could allow the recording (automatically or manually) of real-time observations or incidents, including OSH exposures, directly into an OSH management system and online OSH records and provide access to 'moment of need' information (Knowledge at Work, 2017). AI could be used to analyse this information alongside historical data and provide advice directly to the worker and/or employer. Effective strategies and systems would be needed to ensure that the large quantity of data generated is handled ethically, ensuring privacy and good use of data, in particular medical records.

***Demonstration of compliance:*** constant monitoring with mobile ICT-ETs could be used to demonstrate compliance with OSH regulations or as evidence during investigation of incidents or any alleged breach by the defendant, investigator or regulator. VR or AR could also be used as evidence in a court case to allow members of the jury and/or the judge to explore the site of the incident and see a demonstration of what the OSH investigator/regulator (or defendant) believes happened. AI algorithms, using big data, could be used by companies to achieve very accurate assessment of risks and develop effective prevention measures.



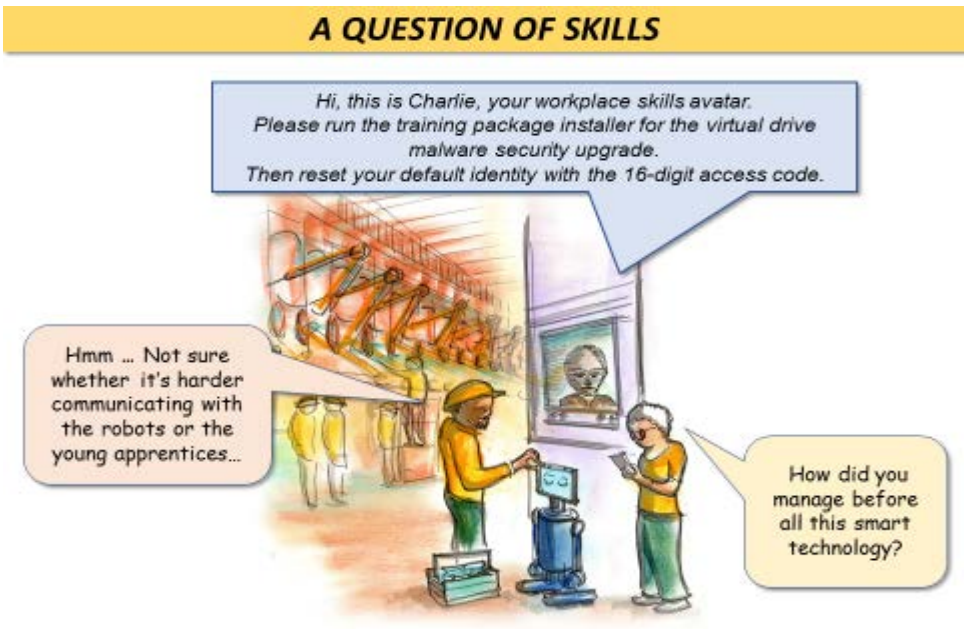
## 5.7 Skills, knowledge and information

OSH challenges and opportunities related to the impact of the use of ICT-ETs on skills, knowledge and information needs and how such needs are met include the following.

***New skills and training needs:*** good-quality learning and training are important for OSH. Increased use of and advances in ICT-ETs could lead to new skills being needed by workers to give them access to good-quality jobs. Workers, as well as needing to know how to use the technology, will need to have the relevant skills for the new ways of working that ICT-ETs bring. For example, workers are likely to need to be self-reliant, flexible, adaptable, resilient, culturally sensitive and competent to work across multiple disciplines. Furthermore, they are likely to need to have interpersonal skills suitable for collaborating virtually. Workers are also likely to need to have the necessary skills to manage their own workloads in a way that is healthy and safe. These traits may improve workers' ability to manage their own OSH, but they are also likely to create a variety of approaches, which may have unforeseen consequences and make regulation and enforcement difficult.

***Lifelong learning*** will be essential, as some skills are likely to have short currency and high value, depending on the pace of technological change and the frequency with which workers change jobs. Workers will, therefore, need to be able to learn quickly and then learn again and again. Depending on the pace of change and how long working lives are extended, people may find themselves doing a job that did not exist when they were children, that is, during their initial education (WEF, 2016), even quite soon after beginning work. The approach to education may, therefore, need to be different, less fact-based and more about how to learn, exchange knowledge and cope with change. Compulsory education will need to lay the foundations for self-reliance, flexibility, adaptability, resilience and cultural sensitivity.

***Self-directed on-line learning:*** the changing business models and nature of work caused by ICT-ETs could mean that workers have to take more responsibility for their own learning and training needs. Some online work platforms, for example, have claimed that they have been hesitant to offer training and development opportunities, concerned that this might be interpreted as the platform acting as an employer (RSA, 2017). ICT-ETs facilitate access to learning and training and allow them to take place on a little and often basis, rather than their being occasional and of long duration. Online learning resources can more easily be designed to allow workers to tailor them to their needs, choosing how they use them and working through them when it is convenient and at their own pace. AI could also be used to assess learners' needs (learning style as well as current level of knowledge) and automatically tailor the resources to meet them. However, it might be difficult for workers to determine, from what could be an overwhelming choice, what is relevant and good quality. This could result in workers' behaviour being based on inaccurate OSH information with potentially poor OSH outcomes as a result.



***Knowledge transfer:*** the potential changes to the nature of work caused by increasing use of ICT-ETs mean that the workforce could be dispersed, frequently changing and online, rather than present in person. Such workers can lack a sense of how their tasks integrate into the overall activities of an organisation and lack the opportunity of tacit knowledge transfer of "real" (as opposed to virtual) interaction with colleagues. A dependence on ICT-ETs for communication could also lead to a loss of social skills or the development of different ones. Either way, this could have a negative impact on social interaction and transfer of knowledge (including that which is essential for good OSH outcomes) between workers, particularly from different generations. In addition, if workers feel unable to interact with their peers, for example because they are being monitored or because of work intensification, this could prevent valuable informal transfer of knowledge. ON the other hand, ICT-ETs can also facilitate new and rapid means of knowledge transfer (e.g. through social media, micro-communities and online work associations), although it may be difficult to assure the quality of the content. ICT-ETs and the changes in the way workers seek and use information could provide an opportunity for regulators, and the OSH community more widely, to engage and inform the self-employed, and micro and small enterprises. Effective strategies and systems are likely to be needed to enable workers to cope with the amount of information available without becoming overwhelmed.

***De-skilling*** will occur, for example, if work is reduced to supervising automated processes that rarely go wrong, or workers are unable to understand how systems work. This could result in workers overseeing the process becoming less and less able to solve problems and to understand systems, processes and decisions made by algorithms and (AI) machines. If the use of AI becomes widespread for decision-making, workers could become dependent on it and cease to be able to make decisions themselves. ICT-ETs can also lead to de-skilling of work, as complex activities become simplified and standardised, so that they require only a low level of expertise and experience. For example, Amazon workers receive precise instructions from machines about what tasks to do and exactly how, including scanners telling them how big a box to use, and small machines that produce exactly the right amount of tape for packing, thus reducing the scope and need for initiative (Dellot and Wallace-Stephens, 2017). Over time, workers´ skills become unused and out of date. This is associated with a risk of an increasing lack of skilled workers who know from experience how to deal with problems. Workers can also suffer from work-related stress if they are not encouraged to use and develop their skills and initiative to do their work and to develop new skills to help them undertake new and challenging pieces of work (HSE, 2017). The challenge is to ensure that systems based on AI do not devalue skilled workers' necessary knowledge and experience.

***Corporate memory:*** ICT-ETs are driving frequent job changes, remote work and the growth of a dispersed, workforce. This could mean a loss of OSH corporate memory and culture, with workers ceasing to know or understand the OSH reasons for doing things in particular ways. The IoT could allow workers to access 'moment of need' training and information, which, if used effectively, could be used as a means of capturing the 'corporate memory' on OSH. However, this could also create an overdependence on electronic information such that knowing where to find information could become more important than remembering information. This might be an issue if, for some reason, it was not possible to access the information, it was corrupted or it was not up to date.

# 6 Conclusions

The digitalisation of the economy, also referred to as the Fourth Industrial Revolution, affects the types of jobs available, how, where and when we work, who works and organisational structures. The emergence of new technologies, such as the IoT, AI, big data, cloud computing, collaborative robotics, AR, additive manufacturing and online platforms, indeed has a profound impact on the world of work. Although the spread and prevalence of the application of ICT-ETs are currently varied across Europe and across different sectors and socio-economic groups, ICT is becoming an integral part of nearly all sectors, rather than a sector of its own. There is evidence that over the next decade there are likely to be significant and accelerating changes in relation to ICT-ETs, which will considerably change the nature and organisation of work across Europe as well as enable new forms of work and employment status. This will have the potential to create business opportunities, including stimulating increased productivity and growth in Europe, with the possibility of growing inequality in the benefits and disadvantages experienced by workers. There could be significant losses in medium-skilled jobs and major gains in higher-skilled jobs, with concerns about a 'race to the bottom' in employment standards. There will also be major changes to the nature of work and the distribution of jobs between sectors. The workforce will be more diverse and dispersed, frequently changing jobs and working online, rather than being present in person. This will all give rise to both challenges and opportunities, including OSH ones. It is difficult to predict these changes, so scenarios of the future, such as those produced during this foresight project, are a valuable tool to help inform policy-makers.

- **Scenarios for the future of OSH**

The key trends and drivers identified in the project, when considered as a whole, imply that the pace of change of digital technologies and how they are exploited in the workplace are likely to be dependent on various factors:

- the level of economic growth and investments in ICT-ETs and skills on the one hand; and
- the demand for and acceptance of ICT-ETs by the public and workers, as well as how governance, management and investment-related decisions support innovations in ICT-ETs on the other hand.

These factors allowed to define four distinct scenarios of the future world of work that were fleshed out with the considerable amount of valuable information generated by the experts, who engaged well with the various means by which they were consulted (telephone interviews, web surveys and workshops).

The four scenarios allowed to identify new and emerging OSH challenges relating to how ICT-ETs could change automated systems, work equipment and tools used; how work is organised and managed; business models, hierarchies, and relationships; the characteristics of the workforce; responsibilities for managing OSH; and the skills, knowledge and information required to work.

Each scenario presents different challenges and opportunities for OSH. The following are some of the differences of note:

- As the pace of change is manageable in Scenarios 1 and 4 (Evolution and Fragmentation), it is not too difficult to keep OSH regulations up to date.
- The only scenario in which there is good investment in OSH research and regulation is Scenario 2 (Transformation).
- Management styles are generally participatory and based on trust between employers and workers in Scenarios 1 and 2 (Evolution and Transformation), whereas in Scenarios 3 and 4 (Exploitation and Fragmentation) the management style is more one of command and control.
- Compliance with good OSH practice is driven largely by social norms in Scenario 2 (Transformation).
- There is a strong desire in Scenario 2 (Transformation) for consensus, which can hold up innovation and regulation.
- All scenarios will involve OSH challenges due to a mix of old and new technology being used alongside one another, although this is best managed in Scenario 2 (Transformation).

Risks that are likely to be present in all four scenarios have also been identified, although their extent and impact may vary. These are:

- the potential for automation to remove humans from hazardous environments, but also to introduce new risks, particularly influenced by the transparency of the underlying algorithms and by human-machine interfaces;
- psychosocial and organisational factors that will become increasingly more important because ICT-ETs can drive changes in the types of work available; the pace of work; how, where and when it is done; and how it is managed and overseen;
- increasing work-related stress, particularly as a result of the impact of increased worker monitoring made possible by advances in and the increasing ubiquity of wearable ICT-ETs, 24/7 availability, blurred boundaries between work and private life, and the online platform economy;
- increasing ergonomic risks due to the increase in online working and the use of mobile devices in non-office environments;
- risks associated with new human-machine interfaces, in particular related to ergonomics and cognitive load;
- the increase of sedentary work, a risk associated with obesity and non-communicable diseases such as cardiovascular diseases and diabetes;
- cyber-security risks due to an increase in the interconnectedness of things and people;
- increasing numbers of workers treated (rightly or wrongly) as self-employed, and who could fall outside existing OSH regulation;
- changing business models and employment hierarchies due to increased online and flexible working and the introduction of algorithmic management and AI that have the potential to disrupt current mechanisms for OSH management;
- the algorithmic management of work and workers, AI, monitoring technologies, such as wearables, together with the Internet of Things and Big Data may lead to a loss of workers' control over their data, issues of data protection, ethical issues, information inequality with regard to OSH, and performance pressure on workers;
- workers lacking the necessary skills to be able to use ICT-ETs, cope with change and manage their work-life balance;
- more frequent job changes and longer working lives.

From an OSH regulatory perspective, there is therefore a potential confluence of factors whereby the use of ICT-ETs drives rapid changes in not only the technologies used at work but also the nature of work, business structures, employment status, hierarchies and relationships; the combined impact of these changes could challenge existing mechanisms for managing and regulating OSH.

There are concerns that (particularly in Scenarios 3 and 4) all this could cause a race to the bottom in employment standards. There are, therefore, OSH implications for businesses, regulators, inspectors, occupational health services, worker representation, education, training and research.

A major challenge for the application of employment and social security laws, as well as for education and training approaches, relates to a more diverse and less well-defined workforce and to changes introducing more flexible working patterns (e.g. on-line platform working), which are expected to be brought about by an increase in the prevalence and spread of ICT-ETs. This is because ICT-ETs allow work to be done virtually anywhere and at any time, and, for many workers, this is expected to fundamentally change the traditional employer-employee relationship. This also results in a blurring of the boundaries between work and private life. The impact of ICT-ETs on the location of work could also make defining work as the place where a person is employed problematic. These changes to the definition of work and workplace challenge the regulation and management of OSH.

- **Need for prompt and proper governance**

Technological developments and the developments to the nature and organisation of work that these facilitate are moving fast and are not always easy to predict, which makes it difficult for regulation to keep up. Policy discussions are on-going but it is important to identify policy gaps and to address them timely.

Examples of OSH strategies that emerged from the discussions in the workshops held as part of this project and that could help mitigate OSH challenges related to digitalisation include:

- the development of an ethical framework for digitalisation and codes of conduct; in particular in the case of AI, there is a need to ensure proper governance of the algorithms and have oversight in place before sophisticated AI is deployed;
- a strong 'prevention through design' approach that integrates a user/worker-centred design approach;
- collaboration between academics, industry, social partners and governments on research and innovation in developments ICT-ETs/digital technologies to properly take account of the human aspects, in order to foster good quality work and good OSH;
- the involvement of workers in the implementation of any digitalisation strategies to identify the tasks best suited to automate and to structure work processes from the point of view of workers being assisted by digital technologies (rather than the other way around);
- advanced workplace risk assessments, using the unprecedented opportunities offered by ICT-ETs, while also considering the full range of their possible impacts in terms of OSH challenges, as identified in this foresight project;
- a regulatory framework to clarify OSH liabilities and responsibilities in relation to new systems and new ways of working;
- an adapted education system and training for workers to enable them to have a complete understanding of digitalised work processes and know how to perform their work safely;
- the provision of effective OSH services to digital workers.

To follow up on this foresight study, EU-OSHA commissioned an overview of regulatory and policy developments in relation to OSH and the online-platform economy in the EU (EU-OSHA,2017b), which was discussed at a high-level seminar in May 2018 (EU-OSHA, 2017c). A number of expert discussion papers were also produced on topics related to digitalisation ([6]). Between 2020 and 2022 EU-OSHA will also run major project that will build upon the findings of this foresight to provide deeper insights into the consequences of digitalisation on workers' safety and health and into the challenges it poses to prevention, OSH management, regulation and policies.

- **The scenarios as a tool for policy-making**

The four scenarios were tested in a workshop (WS2-3), using a futures technique known as policy wind tunnelling. During the workshop, it was observed that the use of the scenarios stretched participants' thinking, created new insights and, in some cases, challenged current assumptions. Policies considered by participants to have benefits in one scenario rarely delivered benefits in them all. This successfully demonstrated that the four scenarios can be used to:

- help inform policy-makers so that they can take appropriate account of changes related to digitalisation, the use digital technologies and the impact on work and OSH when making decisions to shape the future towards safe and healthy workplaces;
- stimulate discussions that incorporate multidisciplinary perspectives about the actions that can be taken today to influence what happens in the future;
- test policies to make them more resilient to the impact of future changes to work as a result of innovation in and the application of digitalisation and ICT-ETs.

The four scenarios have, therefore, been shown to be a valuable tool for analysing future OSH challenges and opportunities. However, they are not forecasts and they should not be treated as a prediction of the future. In fact, the future for OSH for different sectors and regions will contain elements of each of the scenarios in a combination that cannot be predicted. Using the scenarios to develop and test future strategies and policies should reduce risk, and help maximise the potential opportunities and

[6] All EU-OSHA´s expert discussion papers on the future of work (including on crowdworking; robotics; 3-D printing; workers´monitoring technologies: the e-retail sector: management by AI; big data for inspection efficiency; the use of exoskeletons: or performance-enhancing drugs) are available at: https://osha.europa.eu/en/emerging-risks

mitigate the risks. The scenarios are ideal for use in a workshop where they allow a multi-disciplinary approach to considering different perspectives. They should be used as a tool to aid thinking and stimulate discussions about a broad range of futures and how to manage the associated uncertainties.

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# 8 Glossary

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| 24/7 — 24 hours, 7 days a week, that is, continuously. |
| 3D printing — a process for making a physical object from a three-dimensional digital model, typically by laying down many successive thin layers of a material; also known as additive manufacturing. |
| 4D printing — 3D printing with time as a fourth dimension, so that the object produced can change form over time in response to a change in environment. |
| 5G — fifth generation mobile networks, providing faster internet connection speeds than current 4G networks. |
| 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. |
| AGI — artificial general intelligence, or strong AI, is AI capable of autonomously applying intelligence to any problem, flexibly performing intellectual tasks in a manner similar to human beings. |
| 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. |
| AV — an autonomous (or self-driving) vehicle. |
| Big data — refers to the potential of new technologies to produce datasets so large and complex that entirely new data processing applications are needed to capture and analyse them. |
| Bionic exoskeleton — a wearable mechanical outer skeleton that produces or augments human motion, often directly sensing and amplifying its wearer's movements, improving their strength and abilities. |
| Bionics — applying knowledge of natural biological processes to the development of mechanical systems and technology, often to replace a person's missing hands or limbs. |
| 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. |
| Brain drain — a continuing net loss through emigration of highly skilled and educated people from a particular country. |
| Burnout — a type of psychological stress, occupational burnout or job burnout is characterised by exhaustion, lack of enthusiasm and motivation, and feelings of ineffectiveness (it may also entail an aspect of frustration or cynicism), and, as a result, reduced efficacy within the workplace. |
| BYOD — bring your own device: when employees use their own devices (e.g. smartphones or tablets) in the workplace. |
| 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. |

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| 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 provide specific services or products in exchange for payment. |
| Cyber-attack — a malicious attempt by an individual or organisation to compromise and harm computer networks and systems. |
| Cyber-bullying — where individuals are bullied through social media. |
| Deep learning algorithms — refers to a technique involving a family of algorithms processing information in deep 'neural' networks, where the output from one layer becomes the input for the next one. |
| 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 the average time taken by workers to complete specific tasks. |
| Distributive trades — businesses that buy and sell other companies' products for profit, such as wholesalers and retailers. |
| DSE — display screen equipment: used by computers to display information. |
| E-commerce — selling and buying online/over the internet. |
| EMF — electromagnetic field: a physical field produced by electrically charged objects that affects the behaviour of charged objects in its vicinity. |
| Facebook — an online social networking tool. |
| GDP — gross domestic product: the total value of everything produced by all the people and companies in a country, which is used as a measure of economic growth. |
| Gig economy — economy based on working in the form of one-off assignments (rather than on a continuous basis), whereby temporary positions are common and (independent) workers are contracted through on-line platforms for short-term engagements |
| Grey economy — the part of a country's economic activity that is not accounted for in official statistics. |
| HR — human resources. |
| ICT — information and communications technology: technology and software that enable users to access, store, transmit and manipulate information. |
| ICT-ETs — ICT-enabled technologies. |
| 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. |

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| 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. |
| IT — information technology, the application of computers to store, retrieve, transmit and manipulate data. |
| Lights out manufacturing — a method of fully automated production that can run with no human input on site, thus with the 'lights out'. |
| 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. |
| MSD — musculoskeletal disorder: injuries or pain in the body's joints, ligaments, muscles, nerves or tendons that support the limbs, the neck and the back. |
| Nanotechnology/nanotech — involves the manipulation of matter at a level of magnitude between 1 to 100 nanometres (1 nanometre = 1 billionth of a metre). |
| Narrow/basic AI — AI that is narrowly focused and only capable of one task. |
| Offshoring — the practice of basing some of a company's processes or services overseas, to take advantage of lower costs. |
| Open IP movement — a turn towards balancing IP rights with openness to enable knowledge sharing and innovation across different businesses and organisations while maintaining protection for IP income. |
| Outsourcing — obtaining goods or a service by contract from an outside supplier. |
| PRAG — EU-OSHA's Prevention and Research Advisory Group. |
| Precision agriculture — farming based on precise measurement and continuous monitoring to achieve optimal production from inputs, combining data from satellite navigation technology and arrays of local and vehicle mounted sensors. |
| Pseudo self-employment — a situation where employers, to avoid costs such as sick pay or holiday pay, treat as self-employed contractors workers who are really employees. |
| Quantum computing — the attempt to harness the indeterminacy and entanglement of particles at the quantum level to exponentially increase computing power. |
| Remote working — where an individual works remotely from the offices of their employer. |
| Reshoring — the process by which organisations move outsourced manufacturing closer to home, primarily due to concerns about rising costs of labour and/or transport or problems of quality control. |
| Sharing economy — a form of exchange where individuals share access to goods and services. |

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| Smart machines — machines that autonomously sense and adapt to changes in their environment or in their own condition, and can communicate with other machines and systems on a network or via the internet. |
| 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. |
| Technostress — negative psychological link between people and the introduction of new technologies. |
| Trillion — one million million or $10^{12}$. |
| Tripartite — including representatives of government, workers and employers. |
| Twitter — an online social networking service that allows users to post and read short character messages, or ‘tweets’. |
| Virtual workplaces — refers to working online anywhere and any time such that location is irrelevant. |
| VR — virtual reality, an immersive computer-simulated or multimedia-generated experience that can be multisensory and enables the participant to interact with the virtual environment. |
| Wearables/wearable technology — networked electronic devices that can be worn, often monitoring and offering a range functions to the wearer, and that can exchange data over the internet with service providers and other devices. |
| 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. |
| Zero-hours contract — a type of employment contract where there is no obligation for the employer to provide minimum working hours or for the employee to accept work that they are offered. |

# Appendix A — Lists of participants

The following people (listed in alphabetical order) participated in the various workshops (listed in chronological order) held during Work Packages One and Two of this foresight project.

**Table A1: Attendees on 17 October 2016 at mini-workshop WS1-1 in London, UK**

| Name | Affiliation |
|---|---|
| Samuel Bradbrook | HSE Health and Safety Laboratory, United Kingdom |
| Emmanuelle Brun | European Agency for Safety and Health at Work – EU-OSHA |
| Peter Ellwood | HSE Health and Safety Laboratory, United Kingdom |
| David Lye | SAMI Consulting Limited, United Kingdom |
| Jim Norton | Independent director, policy adviser and public speaker; visiting Professor of Electronic and Electrical Engineering, University of Sheffield; Chair of Serious Games International Limited; board member, Foundation for Information Policy Research; external board member, Parliamentary Office of Science and Technology, United Kingdom |
| Ian Pearson | Futurizon, United Kingdom |
| John Reynolds | SAMI Consulting Limited, United Kingdom |
| Nicola Stacey | HSE Health and Safety Laboratory, United Kingdom |
| Annick Starren | European Agency for Safety and Health at Work - EU-OSHA |
| Huw Williams | SAMI Consulting Limited, United Kingdom |

**Table A2: Attendees on 7 November 2016 at the PRAG meeting at EU-OSHA's offices in Bilbao, Spain**

| Name | Affiliation |
|---|---|
| Francisco Jesús Alvarez Hidalgo | European Commission, Directorate-General for Employment, Social Affairs and Inclusion, Unit EMPL.B.3 — Health and Safety |
| Boglarka Bola | European Agency for Safety and Health at Work - EU-OSHA |
| Emmanuelle Brun | European Agency for Safety and Health at Work - EU-OSHA |
| Boel Callermo | Work Environment Authority, Sweden |
| Marine Cavet | European Agency for Safety and Health at Work - EU-OSHA |
| William Cockburn | European Agency for Safety and Health at Work - EU-OSHA |
| Sarah Copsey | European Agency for Safety and Health at Work - EU-OSHA |

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|---|---|
| Dietmar Elsler | European Agency for Safety and Health at Work - EU-OSHA |
| François Engels | Federation of Artisans, Luxembourg |
| Alban Guillerm | European Agency for Safety and Health at Work - EU-OSHA |
| Xabier Irastorza | European Agency for Safety and Health at Work - EU-OSHA |
| Viktor Kempa | European Trade Union Institute - ETUI |
| Lothar Lissner | European Agency for Safety and Health at Work - EU-OSHA |
| Eckhard Metze | Confederation of Employers' Associations, Germany |
| Malgorzata Milczarek | European Agency for Safety and Health at Work - EU-OSHA |
| Lorenzo Munar | European Agency for Safety and Health at Work - EU-OSHA |
| Marko Palada | Independent Trade Unions, Croatia |
| Kate Palmer | European Agency for Safety and Health at Work - EU-OSHA |
| John Reynolds | SAMI Consulting Limited, United Kingdom |
| Martin Röhrich | Confederation of Employers and Business Associations, Czech Republic |
| Katalin Sas | European Agency for Safety and Health at Work - EU-OSHA |
| Elke Schneider | European Agency for Safety and Health at Work - EU-OSHA |
| Michaela Seifert | European Agency for Safety and Health at Work - EU-OSHA |
| Nicola Stacey | HSE Health and Safety Laboratory, United Kingdom |
| Annick Starren | European Agency for Safety and Health at Work - EU-OSHA |
| Mathijn Wilkens | European Foundation for the Improvement of Living and Working Conditions - EUROFOUND |
| Huw Williams | SAMI Consulting Limited, United Kingdom |

**Table A3: Attendees on 12 December 2016 at mini-workshop WS2-1 in London, UK**

| **Name** | **Affiliation** |
|---|---|
| Samuel Bradbrook | HSE Health and Safety Laboratory, United Kingdom |
| Emmanuelle Brun | European Agency for Safety and Health at Work - EU-OSHA |
| Mellisa Collett | Consultant and independent legal professional and tribunal judge based in London, United Kingdom |

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| Mary-Elizabeth Cross | Railway Safety Standards Board, United Kingdom |
| Pavel Dobeš | Technical University of Ostrava, Czech Republic |
| Peter Ellwood | HSE Health and Safety Laboratory, United Kingdom |
| David Lye | SAMI Consulting Limited, United Kingdom |
| Jim Norton | Independent director, policy adviser and public speaker; visiting Professor of Electronic and Electrical Engineering, University of Sheffield; Chair of Serious Games International Limited; board member, Foundation for Information Policy Research; external board member, Parliamentary Office of Science and Technology, United Kingdom |
| Jan Popma | University of Amsterdam, Netherlands |
| Nicola Stacey | HSE Health and Safety Laboratory, United Kingdom |
| Annick Starren | European Agency for Safety and Health at Work - EU-OSHA |
| Huw Williams | SAMI Consulting Limited, United Kingdom |
| Ivan Williams | Institution of Occupational Safety and Health - IOSH, United Kingdom |

**Table A4: Attendees on 6 and 7 February 2017 at workshop WS2-2 in Brussels, Belgium**

| **Name** | **Affiliation** |
|---|---|
| Francisco Jesús Alvarez Hidalgo | European Commission, Directorate-General for Employment, Social Affairs and Inclusion, Unit EMPL.B.3 — Health and Safety |
| Samuel Bradbrook | HSE Health and Safety Laboratory, United Kingdom |
| Emmanuelle Brun | European Agency for Safety and Health at Work - EU-OSHA |
| Anne-Sofie Daleng | Work Environment Authority, Sweden |
| Elsbeth de Korte | Organisation for Applied Scientific Research, Netherlands |
| Pavel Dobeš | Technical University of Ostrava, Czech Republic |
| Peter Ellwood | HSE Health and Safety Laboratory, United Kingdom |
| François Engels | Federation of Artisans, Luxembourg |
| Magnus Falk | Work Environment Authority, Sweden |
| Marina Gomez | European Agency for Safety and Health at Work - EU-OSHA |
| John Harkin | Council of European Employers of the Metal, Engineering and Technology-based industries |

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| Michel Héry | National Research and Safety Institute - INRS, France |
| Ursula Huws | University of Hertfordshire, United Kingdom |
| Viktor Kempa | European Trade Union Institute - ETUI |
| Patricia Leighton | University of South Wales, United Kingdom |
| Jon Messenger | International Labour Organization - ILO, Switzerland |
| Paul Mrozowski | Telefónica, Belgium |
| Claudia Nicoló | Association of Trainers and Security Operators at Work, Italy |
| Kate Palmer | European Agency for Safety and Health at Work - EU-OSHA |
| Geoff Pegman | RU Robots, United Kingdom |
| Daniel Podgórski | Central Institute for Labour Protection - CIOP, Poland |
| Frank Pot | Nijmegen School of Management, Radboud University, Netherlands |
| John Reynolds | SAMI Consulting Limited, United Kingdom |
| Patricia Rosen | Federal Institute for Occupational Safety and Health - BAuA, Germany |
| Nicola Stacey | HSE Health and Safety Laboratory, United Kingdom |
| Annick Starren | European Agency for Safety and Health at Work - EU-OSHA |
| Roger Upfold | Health and Safety Executive, United Kingdom |
| Egon van den Broek | Utrecht University, Netherlands |
| Oscar Vargas | The European Foundation for the Improvement of Living and Working Conditions - EUROFOUND |
| Gérard Valenduc | Catholic University of Leuven, Belgium |
| Patricia Vendramin | Catholic University of Leuven, Belgium |
| Huw Williams | SAMI Consulting Limited, United Kingdom |
| Laurent Zibell | IndustriAll European Trade Union |

**Table A4: Attendees on 29 June 2017 at workshop WS2-3 in Brussels, Belgium**

| Name | Affiliation |
|---|---|
| Francisco Jesús Alvarez Hidalgo | European Commission, Directorate-General for Employment, Social Affairs and Inclusion, Unit EMPL.B.3 — Health and Safety |
| Samuel Bradbrook | HSE Health and Safety Laboratory, United Kingdom |
| Emmanuelle Brun | European Agency for Safety and Health at Work – EU-OSHA |
| Elsbeth de Korte | Organisation for Applied Scientific Research, Netherlands |
| Kate Field | Institution of Occupational Safety and Health - IOSH, United Kingdom |
| Eva Flaspöler | Institute for Occupational Safety and Health of the German Social Accident Insurance - IFA, Germany |
| Sacha Garben | College of Europe |
| Benno Gross | Institute for Occupational Safety and Health of the German Social Accident Insurance - IFA, Germany |
| John Harkin | Council of European Employers of the Metal, Engineering and Technology-based industries |
| Wiking Husberg | Ministry of Social Affairs and Health, Finland |
| Sergio Iavicoli | Italian Workers' Compensation Authority, Italy |
| Viktor Kempa | European Trade Union Institute - ETUI |
| David Lye | SAMI Consulting Limited, United Kingdom |
| Jan Michiel Meeuwsen | Partnership for European Research in Occupational Safety and Health |
| Claudia Nicoló | Association of Trainers and Security Operators at Work, Italy |
| Kate Palmer | European Agency for Safety and Health at Work – EU-OSHA |
| Marko Palada | Independent Trade Unions, Croatia |
| Frank Pot | Nijmegen School of Management, Radboud University, Netherlands |
| John Reynolds | SAMI Consulting Limited, United Kingdom |
| Martin Röhrich | Konfederaci Zamestnavatelskych a Podnikatelskych Svazu, Czech Republic |
| Patricia Rosen | Federal Institute for Occupational Safety and Health - BAuA, Germany |
| Philippe Saint Aubin | IndustriAll European Trade Union |
| Katalin Sas | European Agency for Safety and Health at Work |

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|---|---|
| Nicola Stacey | HSE Health and Safety Laboratory, United Kingdom |
| Annick Starren | European Agency for Safety and Health at Work – EU-OSHA |
| Nina Stone | Work Environment Authority, Sweden |
| Roger Upfold | Health and Safety Executive, United Kingdom |
| Egon van den Broek | Utrecht University, Netherlands |
| Lieve Van Woensel | European Parliament |
| Huw Williams | SAMI Consulting Limited, United Kingdom |

**Table A5: Peer reviewers of the draft OSH scenarios as part of Work Package Two, Task Two**

| **Name** | **Affiliation** |
|---|---|
| Elsbeth de Korte | Organisation for Applied Scientific Research, Netherlands |
| Magnus Falk | Work Environment Authority, Sweden |
| John Harkin | Council of European Employers of the Metal, Engineering and Technology-based industries |
| Viktor Kempa | European Trade Union Institute - ETUI |

# Appendix B — Workshop agendas

**WS1-1**

**Date: 17 October 2016**

Location: Worshipful Company of Information Technologists, London, UK

Objective: to rank the drivers of change and identify the critical uncertainties that will be used to generate potential scenario axes.

13.45 Introduction to the project and workshop (John Reynolds, SAMI Consulting, UK)

13.50 Presentation of shortlisted drivers

14.10 Discussion — to review drivers and identify any gaps

14.30 Exercise 1: Impact and uncertainty matrix to identify the key drivers — plenary exercise using driver cards to look at impacts and then uncertainty

15.20 Break

15.35 Exercise 2: Convert the critical uncertainties into potential scenario axes, as example below — work in groups of two or three to define the potential 'end points' of the potential scenario axes

16.00 Feedback and plenary discussion of potential scenario axes

16.25 Exercise 3: To decide the potential scenario axes — facilitated plenary discussion

16.45 Exercise 4: Plenary discussion of potential scenarios from different combinations of axes

17.40 Conclusions and next steps

18.00 Close

**PRAG Meeting**

**Date: 7 November 2016**

Location: EU-OSHA, Bilbao, Spain

Objective: to inform PRAG members of the progress of the project and to introduce and test the preliminary scenarios.

14.10 Introduction (Emmanuelle Brun, EU-OSHA)

14.15 Presentation of the results of Work Package One, 'Key drivers of change' (Nicola Stacey, HSL)

14.35 Outline of the critical uncertainties and the potential, preliminary future scenarios that they could create (John Reynolds, SAMI Consulting)

14.45 Introduction to the exercises (John Reynolds, SAMI Consulting)

14.50 Exercise part 1: Work in groups, each group considering one of the potential, preliminary scenarios of the future of ICT (including robotics) and work created by the critical uncertainties. The first task will be to discuss the potential impacts of the scenario on the nature and location of work and the linked societal changes.

15.30 Break

15.45 Exercise part 2: Based on the groups' results from part 1, consider the potential OSH challenges and opportunities created by the changes to work and society.

16.20 Feedback and discussion

17.10 Presentation of plans for Work Package Two, 'Scenario development and testing' (John Reynolds, SAMI Consulting)

17.20 Discussion

17.30 Closing remarks

**WS2-1**

**Date: 12 December 2016**

Location: Worshipful Company of Information Technologists, London

Objective: to agree the axes and develop the base scenarios

13.45 Introduction to the project and workshop

14.00 Presentation of priority drivers and potential axes

14.10 Discussion of potential scenarios

14.30 Exercise 1: Generation of two scenarios in groups (Scenarios 2 and 3)

15.45 Break

16.00 Feedback and discussion

16.30 Exercise 2: Generation of second two scenarios in same groups (Scenarios 1 and 4)

17.30 Feedback and discussion

19.00 Close

**WS2-2**

**Date: 6 and 7 February 2017**

Location: Hilton Brussels City Hotel

Objective: to consider the potential OSH implications of the base scenarios (developed earlier in this work package) that describe what the nature of work may be like in four alternative futures.

**Day One**

12.30 Registration and coffee

13.00 Welcome and introduction to the project

13.05 Introduction to the workshop

13.10 Developments in ICT to 2025

*Presentation on trends in ICT, including ICT-ETs such as robotics and artificial intelligence, and how the potential capabilities of these may develop up to 2025.*

13.30 Discussion

13.50 Introduction to the outline scenarios, including discussion

*A set of outline scenarios that define four potential futures has been developed. A summary report outlining these will be circulated before the workshop.*

14.10 Introduction to Exercise 1

14.15 Group Exercise 1: News headlines in scenarios for 2025.

*All the exercises will be conducted in four groups, one for each scenario. This first exercise is an opportunity to discuss the group's scenario and gain a feeling for what if would be like to live in it. This will be summarised by a media headline that could be applied to work in 2025 in the scenario in question.*

14.30 Feedback and discussion

14.50 Introduction to Exercise 2

15.00 Break

15.15 Group Exercise 2: Changes to work in each scenario.

*This will commence with a general discussion of how ICT and related technologies may evolve in the scenario and the impacts on work. Groups will then look in more detail at how existing jobs may evolve, including being fundamentally changed by technology or totally disappearing. It will also be important to explore what new types of jobs may emerge in the scenario.*

17.30 Feedback and discussion

18.20 Closing discussion and plans for tomorrow

18.30 Close

**Day Two**

09.00 Introduction to Day Two and reflections on previous day

09.20 Introduction to Group Exercise 3

09.30 Group Exercise 3: OSH challenges and opportunities

*This will use the groups' outputs from Exercise 2 on how jobs will change or emerge in the scenario. Groups will start with a discussion of the general OSH issues in the scenario, looking at both the new and emerging OSH challenges and the opportunities to mitigate the risks. This will be followed by a discussion of different types of jobs and their respective OSH challenges and opportunities. It will be particularly important to identify where there are major changes to OSH in the scenarios, including new types of OSH risk.*

11.00 Break

11.20 Feedback and discussion

*We will review OSH across the four scenarios and focus on the new and emerging risks. We will also identify those that are similar across the scenarios and those that are significantly different in one or more scenarios.*

12.45 Conclusions and next steps

13.00 Close

**WS2-3**

**Date: 29 June 2017**

Location: Thon Hotel City Centre, Brussels

Objective: to demonstrate the use of the scenarios for policy-making and to test that the scenarios could be used to create useful debates about policy options.

*08.30 Registration and coffee*

09.00 Welcome and introduction to the project (Emmanuelle Brun, EU-OSHA)

09.10 Introduction to the workshop (John Reynolds, SAMI Consulting)

09.20 Presentation on the future of ICT and work (Ian Pearson, Futurizon)

09.50 Presentation of the 2025 scenarios, including OSH (John Reynolds, SAMI Consulting)

10.45 *Break*

11.00 Group Exercise 1: Scenario headlines exercise

11.15 Plenary discussion of scenarios and OSH

11.30 Group Exercise 2: Key OSH challenges and opportunities in scenario

*12.30 Lunch*

13.30 Group Exercise 3: Potential responses to new and emerging OSH issues in the scenarios

14.30 Plenary Exercise: Cross-scenario analysis of responses to new and emerging OSH challenges ('wind tunnelling')

*15.30 Break*

15.45 Plenary discussion

16.15 Conclusions and next steps

16.30 Close

# Appendix C — Data from OSH scenario development workshop (WS2-2)

## C1 Scenario 1: Evolution

### *C1.1 News headlines in scenario for 2025*

#### Discussion

Participants thought that scenario 1 had a lot in common with today and as a result it could be seen as a time of stagnation. The EU was closing its borders against migrants, but there was still unemployment, which participants felt was a contradiction, although it is not. While there is relatively high unemployment generally, there is competition throughout Europe for people with the skills necessary to work in the new technologies, which has caused brain drain. Participants also felt that a further contradiction was that of inclusivity alongside high inequality. Although governments are focusing on social welfare, health and social care, and education, ordinary people are scared. Regulation to protect traditional jobs is not inclusive. As governments focus on people, the funds for innovation are reduced, so technology belongs to big companies and there is a move towards local micro-economies. A lack of the funds necessary to get the best IT makes micro-economies vulnerable to cyber-crime. Big data will be used for social welfare.

#### Headlines

The headlines produced were:

1. ‘EU wake up! Your future is on a slippery slope.’
2. ‘EU strategy fails.’

#### Surprises

There were no major surprises, although the scenario turned out to be not as comfortable as first impressions might suggest. One comment was ‘I wouldn’t like to live in this scenario, but it’s not the worst one.’

### *C1.2 Impact of changes in ICT on work*

#### Technology

The digital divide is a key feature of this scenario and lack of resources means progress is slow, with variability in access to the internet. Some rural areas in particular would experience this. Participants felt that the scenario was too optimistic about the rate of change. Lack of investment would lead to continuing vulnerability to cyber-crime. There would be wide diffusion of existing technologies, but low investment in new technologies. Robots would carry out simple tasks, but there was no funding for robots to do more complex work. Robots would assist workers but not replace them.

#### Crowd-working

There would be increased crowd-working within the framework of the existing informal economy in micro-communities (exchange of services, mutualisation of resource). In France, there are already communities that exchange services through platforms, for example gardening jobs in exchange for care work. Increases in the amount and scale of crowd-working activities could lead to increased risks, as people who are not properly trained or supervised may be using unsuitable equipment. The general public are potentially at risk, as are the crowd workers themselves.

#### Care work

Up to 2020, care is still personalised — humans would look after humans with some assistance from AI and robots. Care could be provided via crowd-work (see above) following the Buurtzarg model — neighbourhood care. ICT will reduce care costs. Towards 2025, telecare with voice control will be widespread where there is good internet cover, resulting in the loss of care jobs.

#### Management

Management jobs will reduce by 50 % because of ICT and AI. This puts more responsibility on workers. However, workers will be allowed the ‘right to disconnect’, so that availability outside office hours is

minimised. New management techniques using new ICT will be developed, so there will be a decreasing need for coordination tasks and an increasing need for high-level professional skills. There is the potential for stress when the boss is AI.

### Manufacturing

Initially, simple robots will make simple things. Increasing use of robots from 2025 could lead to improved OSH as people are removed from dangerous jobs. Later on, increased productivity will be needed to counteract demographic change and there will be increasing numbers of robots, but cheaper models — not the latest. Robots can undertake materials handling and monitoring. There will not be lights out manufacturing yet in this scenario. There will be some use of additive manufacturing. Additive manufacturing in the home will bring risks.

### E-commerce collection and delivery

There will be some replacement by ICT of routine tasks related to packaging, loading, scheduling, tracking, unloading, etc. Risks may arise from workers having to supply their own equipment — vehicles, etc. Workers will be subjected to time pressures and shift work.

### New jobs

- Teachers of the middle-aged and elderly in ICT skills.
- Professional internet trolls (not clear who the clients might be).
- New jobs at the local community level. These are not high-tech jobs but are enabled by ICT.
- New ICT jobs, including cyber-security.
- Scientists and experts in cognitive and behavioural matters.

### Surprises

No surprises were encountered. The group felt that progress would be slow and predictable in this scenario.

## *C1.3 OSH challenges and opportunities*

### General OSH environment — opportunities

- There is general support for OSH across social partners and government. The rate of technical innovation is manageable, so regulation will be able to keep up.
- There will be some AI support for regulatory targeting.

### General OSH environment — challenges

- There will not be much government money for OSH research, so some new risks may be missed or over-protected, but industry investment in technology could mitigate OSH risks.
- Social media might be used as a cheaper alternative to full-blown awareness campaigns.
- The drive for increased efficiency could lead to risk taking. Workers who fear for their job security might be unwilling to complain about OSH risks.
- Inequalities across social, economic and generational divides — low pay — unable to afford new technology.
- Loss of middle management could weaken the OSH situation as quality policies are neglected.
- Crowd-working may introduce wide-ranging risks for both workers and the general public. For example, carers have to lift people, the right equipment may not be available and crowd-workers may not be adequately trained. Crowd-workers will suffer from psychosocial problems — fear that they might not get paid and fear of continual monitoring as clients ‘mark’ contractors. However, there will be a lower level of crowd-work in this scenario — ‘less bad is good!’
- Low investment and brain drain could lead to poor maintenance — ‘who’s going to fix the robots?’

### Risks that are reduced

- Increasing use of robots and automation should reduce risks as workers are removed from dangerous activities. This could reduce exposure to physical, chemical and ergonomic risks.

### New, emerging or increasing risks

- Increased work with robots and automation could give rise to psychological problems. Autonomous vehicles could become a silent danger — audible warnings might be needed.
- Additive manufacturing could increase exposure to toxic chemicals, especially where the work is carried out in small businesses by inexperienced workers.
- Increasing use of ICT could result in increased stress caused by the use of the ICT itself and by the threat of unemployment. BYOD and the threat of cyber-crime along with 'always available' expectations from employers could cause stress.

### Discussions on whether risks identified will increase in this scenario compared to nowadays:

Physical risks: the change is manageable and hazards and means of prevention well known. Automation for productivity removes people from hazards, but connected robots/machines could be vulnerable to cyber-attack.

Chemical risks: the change is manageable. New risks could come from 3D printing or new materials such as composites. However, there could be new risks resulting from the production of chemicals for which trade barriers ban import. Moreover, human exposure will continue, but there is scope for wearables to monitor risks.

Biological risks: there would be new risks resulting from exposure to synthetic biology products, but there might be trade barriers to control the import of biohazards.

Ergonomic risks: owing to an increase in mobile device use, e.g. caused by BYOD. Working remotely will make display screen equipment (DSE) monitoring difficult. 'Smart chairs' could be used to monitor good practice.

Psychosocial risks: there is likely to be a lot of stress in this scenario. In all jobs, fear of unemployment will cause stress. Having AI as a boss could introduce a new source of stress. Remote monitoring or wearables could provide information (or make the situation worse?).

The number of participants who thought this scenario was the most likely to accurately describe the future in 2025 was four out of twenty-five participants.

The number of participants who would like to live in this scenario more than any of the others was nine.

### Surprises

No surprises were revealed. Participants felt that this scenario was rather predictable.

## C2 Scenario 2: Transformation

### *C2.1 News headlines in scenario for 2025*

### Discussion

There was no discussion about what work might be like in 2025. However, concerns were expressed about peer pressure to conform getting out of hand.

### Headlines

The headlines produced were:

1. 'Privacy sacrificed so that technologies have solved the problem of unemployment'.
2. 'ICT has contributed to increased ethical concerns in business models.'
3. 'A new wave (or world) of trust, collaboration and consensus thanks to technology.'
4. 'Workers' voices × technologies, the winning formula.'
5. 'The word colleague removed from the dictionary.'
6. 'The rate of failed conformity tests on the rise for the first time ever — particularly in the countries ….'
7. 'Reservation created for ICT-phobes on island paradise.'
8. 'Peers' exclusion of non-conforming colleague leads to suicide.'
9. 'First robot strike (over poor working conditions) just days after they are granted voting rights.'

### Surprises

The group initially felt very positive about the scenario, referring to it as a dream scenario. Despite the first three headlines being quite positive, the group then became quite negative when thinking about headlines — perhaps as it was the easiest way of producing an attention-grabbing headline.

## *C2.2 Impact of changes in ICT on work*

### Technology

The participants created a hypothetical timeline for the development of AI in this scenario as follows: analysis of data provided by human to provide results interpreted by human > collecting data as well as analysing it and then making recommendations > learning and explaining how it has come to conclusions > developing empathy for end user and tailoring advice accordingly > the right to decide, while still being there in theory, is very difficult in practice because of pressure from peers to accept and potential insurance implications if advice is not followed > accepted view is that the AI knows best > legitimate for AI to make decisions and act upon them.

Human interfacing with machines and one another remotely would become more natural, immersive and seamless. For example, people would appear to be present together although they were all interacting from different locations. It was felt that this would create a levelling of access to information, employment and finance, irrespective of ICT skills, country of origin, social background, age or disability.

Wearables would lead to managers knowing everything about you 24/7 — that is, workers would become transparent.

IoT would continue to expand so that cyber-security would be an ever-increasingly important and potentially challenging job — there was the observation that, despite the value attached to this job, criminals always seem to be one step ahead. It was observed that the increasing dependence on the internet might lead (around 2020) to a fundamental change in the underlying principles, structure and control of the internet.

Drones would be used to do dangerous and difficult jobs or tasks — particularly in agriculture.

Driverless (self-driving, autonomous) cars (and other vehicles) would be in the majority. Car ownership would decline.

The fact that many jobs will change or be lost, but that sufficient new jobs would be created, was used to put the discussions into context. However, we did not have time to explore the fact that this could lead to people changing jobs more frequently.

### Crowd-working

- Crowd-working transcends the political environment of the countries in which the crowd-worker lives, as there is very little difference in how it happens, irrespective of the political culture of the worker's home country.
- Crowd-working formalises the informal (grey) economy and makes those involved more visible (although still hard to reach). Whereas in the old grey economy the money remained in the local economy, it is now going offshore to the owners of the online labour exchange platform. One in forty workers in 2015 are already getting 50 % of their income from crowd-working. However, there is scope in this scenario for local communities to set up their own online labour exchange platforms to keep the money in the local economy.
- There would be a need for some kind of selection process for people to get accepted onto online work platforms, followed by a mechanism for regular quality review — perhaps by peers (e.g. similar to the gas-safe system in the UK).
- There would be mechanisms for assessing, collecting and paying tax via online labour platforms around 2020.
- In the difficult transition in terms of how, where and when people work, there could be peer expectations (real or perceived) for people to be available 24/7. Young people will find it more difficult to disconnect than those who have not grown up with mobile smart devices (who will become fewer the closer we get to 2025). However, by 2025 online platforms will have built-in AI supervision to encourage safe working practices, including spotting unhealthy work intensity and

people taking on jobs that they are not suited to. AI could also supervise online workers, giving them advice and guidance.

- E-democracy platforms for the workforce will be developed (around 2020?) that could be used as tools for the building up of consensus between stakeholders (e.g. workers, employers/customers).
- Soon after 2020, traditional employment hierarchies will disappear and people will be paid according to results rather than hours worked. This will allow people to arrange their work around their home life, but will also blur home-work boundaries and make enforcing a minimum wage difficult.
- Cyber-security will be very important.

### Care work

- The IoT will allow patients to be monitored from home by 2020, with patients/doctors having to go into hospitals only for treatment. By 2020, patients will increasingly be expected to be responsible for their own care, with support from wearables. They will retain the right to decide, but if they fail to follow advice, resulting in increased care costs, then their care budget may be cut.
- By 2020, some medical specialists may be completely replaced by ICT — particularly those who are involved in routine analysis of data for which big data exists, such as radiologists.
- Caring and comforting could not be taken over by ICT/robots.
- By 2025, some surgery could be performed remotely by humans controlling robots or even prerecorded and done later by robots — a bit like catch-up TV.

### Management

- Work is already increasingly flexible and done where there is a geographical distance between the boss and employee, and this trend would continue. At least initially, this will make supervision of employees by their bosses difficult. However, by 2020 ICT will be developed that enables work to be controlled and workers to be supervised from a distance, and this will quickly lead to there being no presence of a human boss.
- Sensors will monitor work time, breaks and work intensity, leading to early detection of work-related health problems, with the data processed by a machine.
- Machines as managers will lead to a reduction in the human aspects of work, the ability to interact socially at work and the possibility of adjusting work to accommodate life situations.
- By 2025, training can be easily taken over by ICT (VR/AR facilitated by AI) and less travelling will be necessary for work because of the use of VR/AR.

### Manufacturing

- Jobs will be lost in manufacturing owing to automation and robotics that enable widespread lights out manufacturing. In addition, owing to a change in attitude about owning capital assets such as cars, there will be sharing or rental on demand.
- Food and other goods will be produced more locally and many things will be grown organically. There will be less availability of meat reared as it is now.
- There will be e-manufacturing centres from which people will be able to order directly from home (via an e-catalogue), and this could include food. These centres could include regional hubs (for distributing the raw materials), but on the whole the distribution centres will be very local (such that people collect themselves) — a bit like the old corner shop. Some e-products may even be delivered as blueprints for production on your home 3D or 4D printer/manufacturing pod (which could include bio-printing).
- Nanotechnology would be used to produce raw materials.
- Clean milking is around the corner.
- Regulations (e.g. on DSE) would fail to keep up with innovation.

### E-commerce collection and delivery

- Jobs will be lost in retail (shop assistants, ticket sales) and delivery (drivers).

- Raw materials (for home or local manufacture) will be transported more than end products and some common raw materials may even be piped directly to homes or local centres.
- Most deliveries will be via driverless (autonomous) vehicles.

### New jobs

- designers of products for 3D and 4D printers
- designers of technology
- producers of new handmade crafts
- brewers
- internet truth/ethics police
- drone police
- maintenance, repair and troubleshooting of robots
- management of co-working spaces
- recycling chemically complex waste
- crowd-worker standing in for a client in a self-service situation, for example standing in line/waiting in virtual queues for time-pressed consumers.

### Surprises

Manufacturing and e-commerce would to a large extent merge.

Design blueprints, rather than the end product, would be where added value resides.

Raw materials would become more valuable and hence need to be efficiently distributed with the minimum of waste and storage, and also efficiently recycled.

While the scenario seems to be very advanced, in terms of the technology used in jobs, there is quite a lot of moving back to old practices, for example type of manufacturing defined by local resources, corner shops, piecework (paid by results rather than hours) and pressure to conform.

## *C2.3 OSH challenges and opportunities*

### General OSH environment — opportunities

- Health is a priority of both the public and government.
- There is funding for OSH research and lots of data.
- OSH is built into design, with effective liaison with the end users.
- OSH is driven by ethics and recognised as good for business.
- The new social contract means that a consensual approach is preferred.
- Trust and shared common values between social partners and government, leading to effective social partnerships.
- Transparency and openness from regulators and social partners.
- Joint learning about OSH issues.
- Prevention activities are generally effective.
- Good-quality self-regulation.
- Low unemployment — work is good for you.
- In general, all opinions are valued.
- Real corporate social responsibility — probably under a new name.
- Use of innovative technology to solve OSH problems.
- A culture of continuous improvement in tackling OSH issues.
- New regulatory mechanisms that include the regulator acting in partnership with other stakeholders, as a facilitator and/or catalyst for much of above.
- Real-time monitoring of and information on potential risks that prevent harm from occurring.
- Common standards for OSH developed across Europe (e.g. exposure limits).
- Dangerous jobs would be automated out.
- Resilience to change and understanding that change will happen rapidly.
- Ability to tailor information to users' personal needs.

- Better ergonomics due to more natural ways of interfacing with ICT.
- Shorter working week?

### General OSH environment — challenges

- The time from design to market would be very short and there would be a lot of pressure to get things to market due to consumer demand and competition.
- There is to some extent a tendency towards an excessively precautionary approach to OSH regulation.
- Preventive measures are not always efficient in terms of time and other resources.
- The pressure to conform to social norms could lead to 'group-think', so that emerging risks were missed.
- Different ways to measure exposure risks (particularly of chemicals) would be needed.
- Getting people to conform to safe practices without losing their vital role in challenging group-think.
- Traditional ways of developing regulations are too slow — for example, DSE regulations are still based on a 1980s view of how we use computers.
- Dependence on sensors to keep people safe could lead to a loss of workers' awareness of risks and of their responsibility to take care of their own safety and health.
- Lack of transparency of algorithms that advise on or make OSH prevention decisions.
- Capacity to assess risks in a fast-changing work environment.
- Not feeling in control.
- We would need to completely rethink how and what we teach so that those entering the workplace had the right skills, taking account of the fact that the technology when a worker is in education could be obsolete by the time they begin work; that is, there is a need to teach problem solving, critical thinking and social skills rather than facts or how to pass exams. However, this change of approach will not suit everyone.
- Low-skilled people will be left behind and could feel alienated.
- Regulations might not be equal for different types of employment status.
- The increase in the numbers of self-employed workers could result in many people being outside OSH regulation.
- Loss of a 'controllable' office environment with the move to remote/home working.
- Cyber-security, in the light of a high degree of reliance on the IoT. Owing to investment, failure would be rare, so people would be less prepared for failure and it would be very serious when it happened.
- Lack of science, technical, engineering and mathematics skills.
- Not having a boss or not knowing who your boss is.
- Lack of clarity about who is responsible for OSH.
- Constant need to adapt to change and adjust to different types of jobs.
- Complexity of systems such that people don't properly understand them and that OSH increasingly needs to use a systems approach because everything is so closely connected.
- High cognitive load.
- Not all people will have the skills to self-manage their time and maintain their skills/continuous professional development.

### Risks that are reduced

- Personalised stress monitoring could provide advice about rest breaks.
- Shorter working week.
- Ability to organise work around personal preferences, resulting in a better work-life balance.
- MSDs would be reduced, owing to more natural ways of interfacing with ICT and machines, and to transport infrastructure catering for mobile workers.
- Maintenance could be done by autonomous robots with AI or remote human supervision.
- Traditional physical, chemical and biological risks would be reduced as a result of increased automation and robotics.

### New, emerging or increasing risks

- Human error due to high cognitive load, de-skilling due to increasing automation or a lack of understanding of complex systems.
- Complexity leading to design errors that introduce latent failure of protective systems.
- Effect of constant use of bionics or exoskeletons on muscles and joints — possible loss of strength and flexibility.
- Sedentary working.
- High visual and voice loads.
- Work intensity.
- MSDs caused by an increase in use of mobile devices with keyboard-type interfaces.
- MSD risks associated with new, more 'natural' ways of interfacing with ICT.
- Psychological risks of being permanently connected/monitored.
- Possible post-traumatic stress disorder-type symptoms if suddenly disconnected.
- Robotics or automation breaking or going wrong, including because of design flaws.
- Maintenance of automated devices and robots.
- Exposure to raw materials for 3D and 4D printing/manufacturing at home or in local manufacturing centres, where micro-enterprises may not have the necessary skills or knowledge to manage the risks.
- Psychological risks due to not feeling in control, loss of social interaction and workplace hierarchies.

### Discussions on whether risks identified will increase in this scenario compared to nowadays:

Physical risks: decreased, primarily because of automation, robotics and drones doing the dirty dangerous jobs, but recognising that automation and robotics can go wrong, can have design flaws and may sometimes need to be maintained by humans.

Chemical risks: decreased, for the same reasons as for physical risks, and also taking into account the use of smart wearable monitoring devices — but not such a good score because of possible new risks introduced by 3D and 4D printing.

Biological risks score: unchanged, because of unknown new risks resulting from nanotech, new biological processes and rising antibiotic resistance.

Ergonomic risks: slightly better, owing to more natural ways of interfacing, designed-in OSH, and changes in transport infrastructure to better cater for mobile working, but also taking account of increased sedentary work, loss of a controlled office environment, continued use of traditional mobile interfaces and the unknown risks of new interfaces.

Psychosocial risks: slightly worse owing to loss of social interaction, increased work intensity and permanent connectivity, but also taking account of the use of wearables with AI supervision to spot signs of stress and encourage safer working practices without the stigma around mental health issues, as a result of the social partnership approach to OSH.

The number of participants who thought this scenario was the most likely to accurately describe the future in 2025 was three out of 25.

The number of participants who would like to live in this scenario more than any of the others was 18.

### Surprises

There is a tension between the removal of traditional risks, thanks to robotics and automation, and the introduction of new ones that would be hard to deal with because of the rapid pace of change and the lack of a full understanding of the impact of innovative ways of doing things.

# C3 Scenario 3: Exploitation

## C3.1 News headlines in scenario for 2025

### Discussion

The group thought that this scenario was characterised by increased inequality and a rise in low-paid jobs, entailing many uncertainties, tensions and threats, as well as increasing fragmentation in Europe.

### Headlines

The headlines produced were:

- '80 % of workers on antidepressants or performance-enhancing drugs to cope with the stress of workplace monitoring.'
- 'Big Brother is watching.'
- 'Taxi app shareholder dividend cut.'
- 'Major car company goes bust, blames shared cars.'

### Surprises

None discussed.

## C3.2 Impact of changes in ICT on work

### Technology

ICT-ETs are primarily used in workplaces for productivity gains, for example algorithms controlling logistics operations. Sometimes this removes individuals from OSH risks, for example through automation of a hazardous operation. In this scenario, there are those who want and accept advanced technology and those who don't want it and have no choice. Individuals find that there is too much choice and some feel overwhelmed. Many are frustrated with the widespread adoption of advanced technology and this causes both stress and anger in some. In this scenario, there is an increasing lack of human-to-human interaction. Technology is likely to make some bad jobs worse, for example in the service sector.

Driving will not be fully automated away by 2025, but roads will have a mix of autonomous vehicles and human drivers. This presents challenges related to managing these mixed modes of transport. There will be an increase in local human drivers (due to more localised manufacturing, including 3D printing), but there will be many autonomous vehicles for long-distance transport, travelling in 'road trains'.

3D printing will be prevalent in local areas and will be used primarily to manufacture repair parts, meaning that warehouses that stock spare parts will disappear. Big manufacturers will lose profit to these local manufacturers; instead, designers of 3D-printed goods will benefit financially. Some manufacturers will become redundant. However, there is an ongoing need for research in material sciences in order to overcome the engineering challenges of creating some 3D-printed objects.

Advances in AI will lead to many routine, repetitive jobs disappearing. This will leave some jobs that are more challenging to automate, such as cleaning. Some will find this work rewarding; others will find them stressful. Examples of jobs that are likely to be automated include logistics and elements of care work, medical work and police work. Not all jobs will disappear; jobs that require intuition and problem-solving skills will still be carried out by highly skilled workers. Most workers will have an AI boss and will be subject to high performance demands through wearables that monitor performance. Some have called this the 'digital whip'.

With lights out manufacturing, could the environment be hostile to humans who need to enter to maintain the systems?

There are OSH issues related to the failure of safety-critical systems due to the legacy of older IT systems and integration with more sophisticated, newer systems.

Some companies, when faced with industrial action, may choose to implement automation much faster than they otherwise would have done, to 'get rid of the problem'.

In this scenario, there has been a widespread rise in the number of ICT systems that are 'open', so these systems are increasingly vulnerable to cyber-attacks, either to cause damage or to hold to ransom an organisation or government. These attacks can affect workplace safety, for example in the case of cyber-attacks on major infrastructure or industrial plants. Companies find it extremely difficult to build safety into these systems.

### Crowd-working

- In this scenario, crowd-work has increased greatly. Most are self-employed workers who need to bid and negotiate like entrepreneurs and sign employment contracts online; do they have the skills to do this? Do they understand what they are signing? Some AI systems provide advice and support for online platform working, for example contract advice. Trade unions could provide or support this service.
- The self-employed will be excluded from training and will have to deal with the social consequences of this. These workers also often work alone for long periods of time, which can cause isolation issues. How can human interaction be built into their work?
- HR recruitment screening processes used by online employment platforms are not adequate.
- Online knowledge workers often have their pay cut; they are not paid regularly, often face a delay before they are paid and are often 'invisible' to OSH regulators.

### Care work

- Robotic technology will change care work jobs significantly, as many activities could be automated, for example lifting patients and dispensing medicine.
- However, there are concerns as to whether a machine can monitor itself sufficiently or provide empathy; can a machine hug you?

### Management

- Management tasks, such as monitoring performance, are increasingly performed by AI systems, but some tasks cannot yet be automated, for example embedding organisational culture.
- Workers also have a need for a human mentor: to help with this, there are some AI mentor systems available online.

### Manufacturing

- By 2025, lights out manufacturing is a reality, with few or no workers present. Owing to lowered costs and technological advances, robots are increasingly prevalent in SMEs and increasingly carry out tasks such as maintenance and repair. However, more specialised jobs, such as plumbing, still remain, as the tasks they perform are hard to automate.
- There has been a growth in 'cognitive manufacturing'; this is defined as an advanced computing system (using machine learning) that can process and analyse all data in the cloud from across manufacturing systems, equipment and processes to create benefits such as increased efficiency, quality and reliability. However, users of these 'intelligent' systems may become de-skilled and may put too much trust in the systems, which could lead to OSH risks.
- There has been a big move towards decentralised manufacturing and a corresponding growth in smaller distribution networks. Local 3D printing will be common, with few workers needed, driven by a demand for mass customisation.
- Collaborative robots are widespread in manufacturing environments, and have significantly reduced physical risks to workers. However, there are some OSH issues related to integrating these robots with a human team and AI systems. Robots are mostly subservient to humans in the workplace. However, workplace systems are becoming increasingly reliant on AI control. Increasingly, maintenance is performed by robots.
- In 2015, there has been a rise in jobs associated with manufacturing, including programmers, data scientists and technicians who service robots and automated systems.

### E-commerce collection and delivery

- The scheduling of deliveries is under computer control, and avatars and virtual assistants interact with customers online, on the phone and 'in person'.
- Drone-based delivery is common, primarily in cities. However, there are still many self-employed delivery drivers.

### New jobs

A rise in local 3D printing has led to a corresponding increase in 3D object design jobs, as well as increases in associated operation, cleaning, maintenance and repair jobs. There has also been a rise in logistics jobs associated with local delivery of 3D-printed items.

There have been big changes in logistics, with the loss of a number of long-distance lorry driver jobs to automation. Most long-distance deliveries are made using automated lorries in 'road trains' from city to city. There are still, however, significant levels of local driving activity.

New jobs are primarily programmers, software developers and computer experts to manufacture and maintain autonomous vehicles and their systems. There are also many jobs associated with electric vehicles such as electric charger, battery and charging network engineers.

There are safety issues around new autonomous vehicles and existing car drivers sharing the road. There is an ongoing lag period as people get used to automated vehicle technology and there have been accidents (partly due to autonomous cars driving differently from human drivers). In addition, drivers commonly operate vehicles and machinery (e.g. mining equipment) remotely.

There are legacy issues from the continued use of older IT systems in industry and infrastructure; these systems have been built upon by newer IT systems. Some knowledge of these systems has been lost or forgotten, or there is a lack of knowledge of how these systems interact with new IT systems. This may present OSH risks related to failure or errors in these systems. There is therefore a need for skills and investment in the forensic analysis of IT systems, including older systems. This is particularly important because in this scenario society is already very reliant on ICT systems, and this is increasing.

There are ongoing, rapid increases in jobs associated with high ICT growth, such as programmers, data scientists, systems analysts, and robot and automated systems engineers to maintain and trouble-shoot them. The advent of quantum computing means that programmers for these computers are now in demand. Owing to increased levels of cyber-attacks, there are many vacancies for cyber-security experts to both develop and maintain safe IT systems. There is demand for individuals with the expertise to understand if an AI system is safe or 'robust' enough.

Psychotherapy and counselling are big growth areas for employment, to help manage the effects of widespread cyber-bullying and the psychosocial issues associated with high levels of intense and often precarious work.

There is also demand for people who can provide advice on how to cope with new technology and work demands. Jobs in sports and leisure activities have also increased, as people seek a break from work demands. There are some who fight back against the rise of high-tech ICT and seek to avoid it by engaging in simpler activities; as a result, professions such as carpentry are undergoing a resurgence.

This scenario has seen the 'rise of the guru', where many individuals seek the services of people who can teach life skills, such as resilience. Those who can afford it choose face-to-face training; others are supported by AI trainers.

### Surprises

None discussed.

## *C3.3 OSH challenges and opportunities*

### General OSH environment — opportunities

There are opportunities to promote OSH messages and training through online platforms and MOOCs.

### General OSH environment — challenges

- Excessive monitoring, work intensification and big rises in online crowd-working mean that many workers are undertaking too much work (many have a number of jobs at the same time), are poorly paid, are in a precarious work position and have a boss who is an AI system. This means that there are high and increasing levels of psychosocial illness at work; stress, anxiety and depression are rife.
- Isolation is a key threat, as there is a continuing lack of interaction between people; this affects skills and lifelong learning. A lack of skills can be associated with negative OSH outcomes.
- There are issues around individuals and their trust in ICT developments, from AI to collaborative robots. There are concerns around whether you can you build trust in these technologies.
- There is a constant need to adapt to technological and wider changes in the workplace and jobs.
- Traditional ways of developing regulations are not fast enough and there is limited capacity to assess OSH risks in a fast-changing work environment. OSH is not a significant concern, unless it impacts on productivity. Any drive to develop regulation will be to protect consumers and the public.
- The complexity of systems is such that people don't properly understand them, and regulators are not able to check whether they are safe enough. There is a lack of transparency of the algorithms that run machinery and systems due to the ubiquity of internet-connected electronic devices at work and new ways of interacting with these devices, such as gesture control and speech. People often feel overloaded by information, which causes stress in many.
- The dependence on ICT to keep people safe is leading to a loss of individual self-awareness when it comes to risks and responsibility for one's own safety and health.
- Many individuals do not feel in control at work. Significant numbers of people lack trust in technological advances.
- It is extremely difficult to monitor OSH, with many individuals undertaking online platform work and remote/home working.
- People struggle to make the time to develop their skills and to manage their time and education.
- Regulators lack funding for OSH, so some are using AI algorithms to help them target positive OSH messages at those in precarious employment.
- The private sector now supplies OSH advice and guidance, filling the gap left by a lack of government investment in OSH; however, the quality of the information is unknown.
- Well-paid jobs are available to those with the right combination of skills, and these workers have access to peer support and the benefits derived from the use of big data.
- In education, there will be a loss of jobs due to the widespread availability and use of MOOCs. Education has become increasingly compartmentalised and convergent. These MOOCs provide choice, but it is not a varied choice.
- Older workers, who have better general skills (having had more work experience), are more in demand than younger workers, who have less experience.
- There may be a role for regulators to influence consumer and public opinion. For example, the bad press associated with a prosecution can have a knock-on effect on company profits.
- There is a need to educate and equip younger people with the skills to look after their own OSH in the future, especially as so many will be self-employed.

### Risks that are reduced

There is a reduction in the number of some hazardous jobs due to automation and robotics.

### New, emerging or increasing risks

- Most work is of a precarious nature and invariably arranged through online platforms.
- There are epidemic levels of psychosocial illness at work, such as stress, anxiety and depression.
- Work intensity has increased generally, across the board. Owing to pervasive automation, there are more work roles of a supervisory nature; as a result, individuals are effectively de-skilled and more prone to error when things go wrong, as they do not understand complex systems.
- Increasingly complex, interconnected and interdependent systems can mean that errors can introduce failures in unexpected areas that can affect protective systems.
- Many individuals are employed through online platforms and many of their work tasks are sedentary in nature. In addition, MSDs result from prolonged use of internet-connected devices.
- Most workers are subjected to high cognitive and visual loads. Others suffer voice health issues, due to increased use of voice-controlled internet-connected devices at work.
- Installation, maintenance and troubleshooting of automated devices and robots.
- There is an increased risk of chemical exposure from the materials used for 3D and 4D printing/manufacturing in local SMEs, at home and in local manufacturing centres, where micro-enterprises may not have the necessary skills or knowledge to manage the risks.

### Discussions on whether risks identified will increase in this scenario compared to nowadays:

There is a vast rise in fragmented work, not counteracted enough by technology in terms of benefits for OSH.

Physical risks despite a number of physical risks being removed through extensive automation, this is offset by some new physical risks, such as increased exposure to EMFs.

Chemical risks there is an increase in new and more complex chemicals being developed and used. There are also legacy issues associated with chemical use in the past. There are, however, rapid ICT developments that have contributed to improved monitoring of chemical exposure at work.

Biological risks there is improved monitoring and control of biological risks, which are also reduced through some automation of work processes. However, there are still biological risks associated with poor-quality jobs.

Ergonomic risks there is the potential for ergonomic risks to get worse, but this is balanced by electronic devices that are increasingly adaptable to the user.

Psychosocial risks there is an increasingly fragmented workforce and the transfer of all OSH risk onto the individual worker.

Many factors that exist today that are leading towards this scenario, such as increases in fragmented work, abdication of governments (in terms of OSH), impact on incomes, and regulatory frameworks becoming increasingly fragmented. There are also other factors that could contribute to this change.

The number of participants who thought this scenario was the most likely to accurately describe the future in 2025 was 13 out of 25.

The number of participants who would like to live in this scenario more than any of the others was one.

### Surprises

None discussed. However, it is interesting that although in this scenario the introduction of automation and robotics is driven by the goal of increased productivity, it also improves OSH by removing workers from hazardous environments.

# C4 Scenario 4: Fragmentation

## *C4.1 News headlines in scenario for 2025*

### Discussion

The group had the insight that 'inertia' was not the same as 'status quo' — in fact, it would be a lot worse! We are on the path towards this scenario already, but the decline could accelerate.

### Headlines

The headlines produced were:

10. 'Shock: no major new innovations in the EU in the last 5 years.'
11. 'The rich/poor divide extends again — more people are falling behind in big areas of poverty.'
12. 'Tax revenues hit new low — avoidance rates higher than ever.'
13. '5 million skilled jobs left unfilled — lack of investment in training blamed.'
14. 'Rise of the "see-through worker" — we know all about you.'
15. 'ICT is your best-enemy and worst-friend.'

### Surprises

Few, because of the lack of investment.

## *C4.2 Impact of changes in ICT on work*

### Technology

Owing to a focus on cost reduction, robotics is employed quite extensively. Existing massive investment in robotics in China feeds through in due course. This brings benefits in reducing risks in hazardous situations and limiting the need for heavy lifting, but it can also cause task deprivation. There may be more jobs for people with disabilities as robotics can remove the need for a certain level of physical capability. Low levels of investment lead to sub-optimal robotics and poor-quality innovation, with associated risks. The technology is brought in with a short-term focus, so there is not enough attention to job and workplace design, and risks resulting from people working alongside robots may increase. But as long as somewhere there are low-cost workers, the implementation of robotics is limited.

There is little innovation in AI, with it remaining specifically task-related, rather than AGI. This limits the types of jobs that become automated to those that are more routine, rather than AI making inroads into the professional sector.

Autonomous vehicles reduce driving jobs and accidents, but poor implementation means there are still some accidents. There are debates about responsibility in these cases, but typically the large corporations seek to avoid liability.

AR and VR are used for training in hazardous conditions, resulting in reduced costs of operation and fewer disruptions to production.

ICT enables 24/7 working, which, in this scenario, brings increasing pressure and stress for most, although it offers some flexibility for the elite. It also brings a blurring of work-life boundaries, with people working at home and organising personal life at work.

Technology is generally introduced to reduce costs rather than improve quality.

### Crowd-working

- Larger corporations manage the platform economy, pushing down wages and standards; the profits accumulate to the platform owner, often abroad.
- This drives an extension of the gig economy, with financial precariousness for many.
- The expanding grey economy also uses informal crowd-working to share work around people's social circles, possibly in a barter style and cash-in-hand to avoid tax.

### Care work

- The key feature of technological development in the care work sector is the increased use of electronic monitoring — of staff, patients and the worried well. Close monitoring of care workers is used to control their activities and use of working time. Remote monitoring of patients is used by employers to reduce the number of visits they need to receive and so reduce the number of staff needed. Preventive health monitoring is the preserve of the elite, so health inequalities increase.
- There is also a place for robotics, used to reduce risks in the lifting of people (and reduce the number of staff to do so), thus reducing injuries.

### Management

- As with care workers, monitoring increases management control and reduces room for individual initiative. Sensors in hazardous conditions and for stress reduce workplace accidents (implemented because accidents disrupt production).
- AR and VR are used to reduce the cost of training and improve productivity.
- Poor cyber-security means companies are less willing to allow teleworking, because they seek to keep control over their data onsite.
- Improved analysis of processes through IoT and big data enables an increase in productivity, with a focus on cost reduction.

### Manufacturing

- As described above, the incentive to use robotics to automate as many jobs as possible to reduce costs remains strong.
- 3D printing, however, is not expected to flourish as, in a poorly regulated environment, quality remains poor and levels of trust low.
- Cyber-security becomes a safety issue as machines get hacked.

### E-commerce collection and delivery

- Increased monitoring of couriers allows tight control of delivery schedules and increases pressure on them.
- In this scenario, e-commerce has not increased and the concept of local collection centres takes hold, as they are cheaper than home delivery. AVs and drones are not much used in home delivery because of the complexities involved, but some are used in transporting products from factories to collection centres.

### New jobs

- With its slower development and lower investment, this scenario does not exhibit the growth of many new jobs. The implementation of new robotic applications creates opportunities in their design, creation and conception.
- The financial uncertainties of the grey economy lead to a growth in the number of personal counsellors of many kinds — themselves often within the grey economy and so of varying quality and reliability. Areas such as digital detox, privacy, crowd-funding and productivity enhancement are ripe for attention.
- Although Bitcoin remains a limited development, it attracts several currency speculators.
- The increased threat from cyber-crime creates new and wider opportunities for cyber-police to combat it.

### Surprises

Few, because there is generally an accelerating decline, with less investment and innovation. That does have the upside of making the rate of change manageable, and it restricts the types of jobs that are automated.

## C4.3 OSH challenges and opportunities

### General OSH environment — opportunities

- Increased monitoring and IoT mean that it is now possible to provide timely alerts of dangerous situations and help people to avoid mistakes. AR means that the relevant information is provided at the right time without the need for extensive written manuals that go unread.
- To some extent, the grey economy allows for greater autonomy and personal control, potentially involving people in managing their own risks.
- Lower investment means slower change, so OSH experts can adapt more easily.
- There are some better planned organisational-level interventions, where clear responsibilities are assigned, primarily to manage costs and reduce disruption.
- 24/7 ICT creates some opportunities to manage work-life balance.

### General OSH environment — challenges

- In general, OSH is harder to regulate in this scenario, with less money being invested in OSH and training. Investments are made in cost reduction, not quality improvement.
- Several developments lead to increased psychosocial pressures and stress. There are financial pressures from unemployment, precarious jobs and the gig economy. Increased monitoring leads to increased performance pressure and a feeling of lack of personal control. Greater use of robotics reduces personal contact and increases isolation, with poorer communication leading to social strain and a lack of informal training. Less job variation leads to increased monotony. The 24/7 world creates information overload.
- Regulations cannot be so successfully enforced in the grey economy. From poor ergonomics in workstations to lack of compliance in construction work, risks increase.
- Machines cannot be perfect, so there will still be accidents, especially where people and robots work together. The reliability of AI and IoT systems will also not be perfect, so there will be occasions where wrong advice is given or wrong decisions are made.
- ‘Sitting is the new smoking’ — fewer incentives to break from a sedentary lifestyle.
- Despite their benefits, AR systems risk distracting people from their real environment.

### Risks that are reduced

- Jobs are lost to automation, so there are fewer dangerous situations where people are exposed to risks, either physical and chemical/biological. There are fewer people in hazardous environments and better monitoring to alert workers to the presence of hazardous substances. Robotics also provides relief from heavy lifting and repetitive strain injuries (RSIs).
- Automation also delivers less stressful client interaction (e.g. bank clerk versus ATM).
- More telework means less traffic, and so fewer road accidents.

### New, emerging or increasing risks

- The increase in personal consultancy, much of it through the grey economy, brings quality-control challenges.
- There is a big increase in the number of cyber-threats. Cyber-security is poor, so there are major hacking risks due to lack of investment.

### Discussions on whether risks identified will increase in this scenario compared to nowadays:

Physical risks shift in the type of risks as many risks are automated out, but ‘sitting is the new smoking’, and there is less training.

Chemical risks: slightly reduced owing to robots, wearables and monitoring control risks, but again there is low investment in training.

Biological risks slightly reduced, for the same reasons as for chemical risks.

Ergonomic risks slightly reduced, owing to better design but greater risks in the grey economy.

Psychosocial risks: highly increased owing to stress caused by surveillance and pressure; some benefits from better alerts.

The number of participants who thought this scenario was the most likely to accurately describe the future in 2025 was seven out of 25.

The number of participants who would like to live in this scenario more than any of the others was zero.

### Surprises

Relatively few. The lower speed of development means that it may be easier to adapt to and anticipate risks.

# Appendix D — Data from scenario testing workshop (WS2-3)

## D1 Scenario 1: Evolution

### *D1.1 OSH news headlines in scenario for 2025*

#### Discussion

The working group agreed that the slow pace of technological change was credible, and the idea of 'Fortress Europe' in the scenario echoed recent calls by European leaders for a 'Europe First' policy. They also agreed that health and social care employment was a credible growth area. Some members of the group queried the low growth in the scenario, given recent encouraging trends in European GDP.

The group noted the loss of jobs in some sectors; it would be important to understand which sectors these would be. The group also thought that the growth of AI would be led by global corporations, and so the way in which many AI machines were programmed would take a global, rather than a regional/European, perspective. The group picked up on another idea in addition to the scenario of a 'brain drain' of talented people out of Europe; they felt that there might also be a 'brain drain' within Europe, from the poorer, less developed areas to the wealthier ones.

#### Headlines

The headline produced was: 'Gig economy workers out of reach of OSH'.

### *D1.2 OSH issues in this scenario*

| OSH issue | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| Opportunity | Micro-communities of interest allow greater flexibility, creativity and sustainability. | Such communities may exist in all major sectors. | The effects are local: greater autonomy and choice for local people, and more opportunities for learning and development, as well as OSH. |
| Challenge (and opportunity?) | The gig economy excludes people from OSH, even if the government aims to be supportive. | Professional, administrative and ICT. | The potential opportunity is the extent to which people in the gig economy and in certain organisations — e.g. trade unions — manage to be creative and innovative in finding ways to reduce this isolation, for example through the use of social media and other forms of networking to share information and best practices on OSH. |

| OSH issue | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| Challenge | Sustainability in the face of external economic forces (and competition within Europe). | All sectors affected, but ICT likely to be affected earliest. | As the scenario description indicates, there is likely to be a crisis point in this scenario, where the effect of low economic growth, slow adoption of technological change and falling living standards for many people heralds a point of crisis in maintaining OSH. |
| Challenge (and opportunity?) | Those people in precarious employment are placed under great stress by loss of autonomy; inability to plan financially (e.g. mortgages); uncertainty about the future; and questions about the long-term affordability of pensions and health insurance. | Professional, ICT and administrative sectors are most affected (others live with these uncertainties to some extent already). | As with the gig economy point above, there is also the opportunity for people to pursue alternative lifestyle choices — living more for the present, travelling, moving between jobs, etc. |

Looking at individual sectors:

- **Manufacturing** — basic jobs continue to be lost, and the jobs that remain change (more to do with supporting mechanised manufacturing than doing the manufacturing); people in this scenario will need to retrain. The limited growth in this scenario means that the pace of change is manageable. There will be fewer industrial injuries.
- **Distribution, transport and storage** — former 'drivers' may still sit in attendance on autonomous vehicles (as pilots do on aeroplanes that largely fly themselves), but they will have less autonomy and utilise fewer skills. People will be monitored more closely; stress levels will rise. There may be more maintenance jobs, although in the longer term machines will maintain other machines.
- **Construction** — there will be more automation (e.g. autonomous/remote-controlled cranes). But remaining construction workers will benefit from new technology, such as exoskeletons, and sensors to measure exposure and tiredness.
- **Administration and support services** — automation will continue to reduce employment opportunities; more administrative support roles will move into the gig economy (e.g. freelance personal assistants working from home). These workers will be harder for conventional OSH to reach.
- **ICT** — the trend towards self-employment and home working will continue; crowd-working will threaten some areas of paid work. As with administrative workers, OSH will not be as easily able to reach ICT workers; they may also suffer from psychosocial problems, as most of their interactions will be with IT rather than other people.
- **Professionals** — there will be growing use of interim managers and employment will become more precarious for professionals. Again, there will be psychosocial problems arising from loss of status and financial expectations**.**

## *D1.3 OSH policies and actions to achieve the best OSH outcome in this scenario*

| Description of action/policy | Expected OSH benefits | Implementation |
|---|---|---|
| **Opportunity**<br>Micro-communities | • Autonomy<br>• Social and technological Innovation<br>• Well-being<br>• Reduction of risk through collaboration and cooperation | • Networking and sharing best practices (including on OSH). Actors: OSH workers, local government, social media, workers themselves.<br>• Micro-finance helps support start-ups and insure against risks. Actors: regulators (looser banking regulations), technical innovators.<br>• Online tools allow people to monitor their own OSH better. Actors: OSH workers and tech entrepreneurs.<br>• Trade unions encompass self-employed workers as well as employees. |
| **Challenge**<br>Finding new ways for OSH to reach gig economy workers | • Reduce stress<br>• Improve safety and health<br>• Reduce isolation<br>• Assist in financial planning | • Networking and sharing best practices (as above).<br>• OSH needs to risk-manage and target worst employers rather than trying to encompass all. Actors: OSH workers, trade unions, social media networks.<br>• Innovative ways of bringing OSH information to people's attention (e.g. when tax authorities process self-employed tax returns). Actors: government agencies, social entrepreneurs, OSH workers.<br>• Micro-finance for risk pooling and mitigation (as above). |

| Description of action/policy | Expected OSH benefits | Implementation |
|---|---|---|
| **Surprising/novel**:<br>The upside to precarious employment | • Greater autonomy<br>• Innovative ways of transferring OSH awareness and learning to this new economic world | • Networking (as above), including potential links to local communities of interest.<br>• OSH agencies focus more explicitly on self-employed and gig economy workers.<br>• Tax rebates and other incentives for companies that encourage learning and development. Actor: government. |

**New jobs and issues**

- Widening divide between educated/skilled and uneducated/unskilled.
- Migration from east to west in Europe mirrors the brain drain out of Europe.
- Growth of homeworking — issues of isolation and OSH.
- People who do have work are driven harder and scrutinised more closely; rewards are higher, but so is stress and loss of autonomy.
- The growth of communities of interest seeds local concentrations of expertise and experience.
- Micro-communities of interest are less dependent on national government — more sustainable, more flexible working and more use of local forms of currency.

**OSH issues**

- Foreign competition threatens to sacrifice OSH in a race to the bottom.
- Technology offers new ways to inform people about OSH and screen risks.
- Use of social media to reach home workers.
- Emerging best practice from communities of interest provides examples for the future.
- Greater stress for those in precarious work (uncertain work, financial insecurity) is mitigated, for some, by opportunities to adopt alternative lifestyles.

## D1.4 Wind tunnelling of policies and actions from other scenarios

| Strategies proposed by the other scenario groups | Ranking –5 to +5 | Comments from scenario group 1 |
|---|---|---|
| Proposed by scenario group 4: Self-reliance | +4 | The principle of self-reliance was very applicable to Scenario 1 as well as Scenario 4. In fact, we had worked up a very similar proposal, although the group had some reservations about using the general medical practitioner as a vehicle, and relied more on communities of interest — or micro-communities (see below) |
| Proposed by scenario group 1: Micro-communities | +5 | This was felt to be a critical positive aspect of Scenario 1. As well as being an important driver of economic and social change, the workshop discussion concluded that the government's supportive role, combined with its lack of resources directly to manage change, necessitated a policy of 'Trust the People'. |
| Proposed by scenario group 2: Automating work in hazardous environments | –5 | The slow rate of technological progress and GDP growth made this an unlikely proposition for Scenario 1. |
| Proposed by scenario group 3: Self-regulating professional bodies | –5 | The strongly regulatory aspects of this proposal (licensing of people to practise) was reminiscent of the historic role of guilds, and was seen as strongly counter to the more diffuse approach inherent in reliance on local micro-communities and the principle of 'Trust the People'. In addition, government, with its limited resources, would not be able to afford to administer such a tightly regulated system. |
| Proposed by scenario group 4: Health monitoring | +3 | This idea had been discussed and was felt to be quite relevant to Scenario 1, at least in some sectors. |

## D1.5 Plenary discussion

- Recent political statements about 'Europe First' might be taken as an early indicator of Scenario 1.
- Micro-finance emerged as a vital component of Scenario 1, to facilitate the financing and management of risk in micro-communities.
- Some group members felt that the brain drain effect would be replicated within the EU.

### *D1.6 Comments on the scenarios*

- The group initially had some reservations about Scenario 1, but in the course of the workshop became more confident about its feasibility and the opportunities and challenges involved in it.
- The micro-communities emerged as a key difference between Scenarios 1 and 4.

At the end of the workshop, members of the group thought Scenario 1 was a desirable scenario, despite the risk of a 'crunch point' being reached.

## D2 Scenario 2: Transformation

### *D2.1 OSH news headlines in scenario for 2025*

#### Discussion

There was some debate about whether those who 'disconnect' would really be the underclass or the privileged few who would be able to choose to disconnect. In addition, the pressure to conform would mean that people would feel the need to maintain a high level of performance and productivity.

#### Headlines

The headlines produced were:

1. 'Striking workers demand delivery of performance enhancing drugs and bionic implants.'
2. 'All dwellings in first gated internet-free community sold before foundations are laid.'

### *D2.2 OSH issues in this scenario*

| OSH issue | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| Dirty, dangerous and hard physical jobs would be automated | This would remove people from harm but what happens to the people who lose their jobs?<br>Automated systems, robots, etc., would still need to be maintained by human workers sometimes.<br>The relatively high pace of innovation could lead to design flaws not being spotted before technology was put into service, leading to unpredictable failure. | Many, including those where automation is currently used and those where it is not currently widely used.<br>Manufacturing<br>Construction<br>Waste and recycling<br>Agriculture | In this scenario, it is anticipated that new, more satisfying jobs would replace those lost.<br>Maintenance is a higher-risk task than normal operation. However, owing to the OSH environment in this scenario there is also likely to be innovation in predictive planned preventive maintenance and use of AR to ensure safe maintenance practices. Furthermore, owing to the fast pace of change |

| OSH issue | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| | The pace of change could lead to integration risks when new innovative technology is frequently incorporated into existing processes. | Forestry<br>Distribution<br>Healthcare | and availability of funds, many companies may replace equipment before any significant maintenance is required. |
| | A culture of innovation is likely to lead to technology designed for one purpose being used for another for which it was not designed. | | Potential for design flaws or repurposing leading to injury would be mitigated by a culture of built-in OSH. |
| AI thinking cul-de-sac | The widespread use of AI has the potential to create dependence as people have to do less and less thinking for themselves. | Most | People could lose their ability to think in a way that is crucial for adapting and coping when things go wrong. We would need, therefore, to find a way to maintain our ability to think for ourselves. |
| Education that is fit for the future | Many children in education will end up doing jobs that did not yet exist when they were learning, so a fact-based education will not be appropriate. Learning to learn and interact effectively with technology and other workers with different knowledge and experience, often remotely, will be important. | Most | Education will need to be fundamentally different to ensure that we have a workforce that is fit for the future. It would need to be lifelong and accessible to all. An apprentice-type approach might need to be more widespread. Individuals, businesses, educators and government will all need to play a role and work together to develop and deliver an effective education system. |
| Generation gaps in ICT skills, including social and business interaction | Workers are likely to have to learn how to use new ICT-based tools and new ways of working and interacting with their colleagues several times throughout their careers. This could be more difficult if major changes occur close to retirement. | Most | Businesses may need to be flexible enough to accommodate a wide range of generations who will have grown up doing things a certain way, and differently from other generations. Lifelong learning that is accessible to all and promotes adaptability to change will be essential to avoid later generations becoming excluded or trying to protect their way of working such that they exclude the new ways of working of upcoming generations. Reverse- |

| OSH issue | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| | | | mentoring will be needed and possibly also generational interpreters or interfaces. |
| Assistive technologies | Would eliminate or reduce manual handling risks but could also create dependence, leading to excessive use and to loss of bone and muscle density and even joint flexibility. Bionics and exoskeletons could also malfunction, causing injury to the user. | Manufacturing<br>Construction<br>Waste and recycling<br>Agriculture and forestry<br>Distribution<br>Healthcare | Rather than exoskeletons and bionics, cobots could be used alongside workers, but this would introduce risks of impact and collision. |
| Lack of transparency of AI algorithms | The underlying algorithms of AI would not be transparent, as they are self-learnt, so it would be difficult to know how they are making decisions. Developers of the AI would not necessarily share the underlying framework or objectives that drive the AI. It would be almost impossible to analyse AI to discover any of this. | Professional<br>Civil service<br>Healthcare | The bases of decisions and whether they were appropriate would be unknown, unless AI was required to explain/justify its decision. Developers of AI would need to be motivated to underpin design with an ethical framework that matched the ethics of society as a whole.<br>Humans have developed coping mechanisms for interacting closely with other humans who do not understand their own underlying ethical framework or decision-making processes. |
| Monitoring using wearable technology to keep workers safe (smart PPE) | Could warn workers of any OSH risks so that they could take avoiding action. | Anywhere that there is the potential for exposure to hazardous substances, extreme environments or stress | Would provide health surveillance data specific to worker and collated data to flag up recurring issues to employer. In this scenario, it was felt that the worker would own their data and the employer would only receive collated anonymised data. However, due to the onus being put on the individual, they might be tempted to ignore warnings or not take medical advice when they should. This could be mitigated by the pressure to conform to social norms. |

| OSH issue | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| Multidisciplinary working becomes the norm | Different cultures, protocols and terminology used in different disciplines may hinder good-quality knowledge transfer. | Most but particularly professional | Could be facilitated through co-working spaces. People would need to be educated and trained to do this well. |
| Unforeseen, unplanned, unpredictable growth of big interconnected systems. | This could result in important systemic risks that could impact on all aspects of our lives if they failed. Examples:<br>• 2008 banking collapse;<br>• major internet outage if one or two subsea cables are damaged;<br>• reliance of a mass of systems on relatively delicate GPS. | Most | Also impacts on whether we are able to work or not and how we are able to work. |
| Effective OSH depends on workers and employers being able to negotiate working conditions. | If in the future information is fragmented for workers (e.g. no collective voice or place of work), overly complex (highly technical) or not available (closed monitoring systems), then there will be a major power imbalance, reducing workers' capacity to negotiate. | Most | Unions will have to diversify their representation and recruiting methods.<br>As the employee-employer relationship becomes vaguer or disappears, responsibility for minimising risks will have to rest on those who have most control of the work process. |
| Current approach to OSH regulation won't be able to respond effectively to pace and variability of change. | Could lead to ineffective 'knee-jerk' responses, such as the 'cookie warning bar' to protect privacy. | Most | There is a need for new and innovative approaches to regulation that are less prescriptive (e.g. underpinned by an ethical and regulatory framework that sets out fundamental principles, allowing more agile local implementation). |

| OSH issue | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| Definition of work likely to have to change. | If people have a guaranteed minimum income, they may do unpaid work. | Social care<br>Craft<br>Legal<br>Distribution<br>Transport<br>Education and training<br>Probably others too | Charity work/volunteering is already covered by OSH regulation in some countries but probably to a limited extent. Such provisions are not generally proactively adopted and are not easy to enforce. |

There is a general trend today towards self-learning using online resources, which also tends to be of the 'little and often variety' rather than occasional and of long duration. There is also a trend towards self-diagnosis, which could lead to self-treatment.

Online self-learning and work could lead to a loss of social skills or the development of new/different ones. Either way, this could have a negative impact on social interaction and knowledge transfer between the generations.

Technology will create better access to work for those excluded at the moment as a result of location or physical disability.

Automation will make countries with low-cost labour less competitive, leading to reshoring of work activities.

Work will be more service-oriented and also about oversight rather than doing.

Workplace and technology innovation need to complement one another; work and workplace design will be important.

If OSH responsibilities are transferred to workers, they will also need the knowledge, skills and tools to empower them to discharge these responsibilities.

Worker representation and cooperatives have a key role to play in ensuring worker-centred design of workplaces, activities and equipment, or at least worker participation.

## *D2.3 OSH policies and actions to achieve the best OSH outcome in this scenario*

| Description of action/policy | Expected OSH benefits | Implementation |
|---|---|---|
| **Opportunity**<br>Automation removes people from dangerous jobs | This would remove people from harm. | This would only happen if there was a lack of cheap low-skilled labour or the social contract was a very strong driver. Upskilling of workers to increase the wages that they could demand would be needed. A guaranteed citizen's income would also remove the availability of cheap labour. |
| **Opportunity**<br>User-centred and participatory design of work activities and ICT-enabled work equipment | This would significantly reduce risk of harm (physical and psychological) resulting from poor design (e.g. reducing stress and/or motivation to misuse/disable safety features or the probability of hazardous malfunction or hazardous maintenance). | Regulatory requirement reinforced by ethical basis of new social contract. Access to good-quality evidence-based OSH information. Good-quality open and transparent OSH research that takes advantage of data from wearables. Privacy regulation that protects individuals' data while also making it available for research and OSH management purposes, including health surveillance and occupational health services. |
| **Challenge**<br>Ability of OSH regulation to understand how AI is making decisions<br>Ability of workers to work alongside AI if decision-making is not transparent | Avoiding risk of harm caused by misunderstandings/misinterpretations between AI and human workers. | New monitoring and risk assessment instruments, tools and techniques would need to be developed that could cope with the lack of transparency, that is, that would be able to interrogate systems and machine learning using large datasets. Regulation to require AI to explain decision-making and to ensure that human workers are able to overrule decisions. It should be noted that humans have already developed coping strategies for working with fellow humans whose decision-making is not transparent, which include judgement, challenge and overruling of decisions. |

| Description of action/policy | Expected OSH benefits | Implementation |
|---|---|---|
| **Challenge**<br>Current approach to OSH regulation's ability to respond effectively to pace and variability of change | New risks need to be recognised in time to 'fix' them in a meaningful way before harm occurs. | An ethical and regulatory framework that sets out fundamental principles allowing more agile local implementation is likely to be required, maybe something along the lines of society's response to genetic modification, artificial reproduction, etc. (e.g. Human Fertilisation and Embryology Authority was set up in the UK). |
| **Challenge**<br>All workers, including self-employed workers are able to challenge poor OSH practice. Gig workers tend to be among the more vulnerable in society and do not naturally collectively organise themselves to enable their concerns to be heard. | Reinforcing of new social contract that ensures good OSH is built into work activities for all, irrespective of employment status. | Accessible OSH information. Lifelong learning to ensure workers are empowered and have the necessary knowledge and skills (technical and social). Governments would need to set up mechanisms to enable effective worker representation so that concerns could be raised and to ensure that they were acted upon. This would need to be both independently of and in partnership with business, particularly owners of online work platforms. |
| **Surprising/novel**<br>No organisation could be too powerful to fail or comply. Businesses would need to buy into the new social contract. | To ensure AI is making safe decisions. | Education and strong government leadership are needed to support ethical business practices and the open IP movement such that businesses are open about the underlying principles and algorithms. There will also be a need to use AI to interrogate and test AI with a view to identifying potentially hazardous decision-making algorithms or underlying principles/frameworks. Businesses may need to sign up to the social contract in order to have a 'licence to operate', without which they would be denied access to workers, consumers and other societal support structures and services. |

Taxing of intangible assets was also mentioned as a means of funding the guaranteed minimum income.

## D2.4 Wind tunnelling of policies and actions from other scenarios

| Strategies proposed by the other scenario groups | Ranking –5 to +5 | Comments from scenario group 2 |
|---|---|---|
| Proposed by scenario group 4: Self-reliance | +3 | In scenario 2, there would be a smaller role for the medical general practitioner, which would be to work with an occupational health professional, who would provide advice to the worker. We also felt that government would need to facilitate and provide funds. A key feature of our scenario was worker empowerment to hold businesses and governments to account, rather than self-reliance. As part of the new social contract, tax and insurance would be among the drivers that encouraged safe and healthy behaviour, alongside social norms. |
| Proposed by scenario group 1: Trust the people to own the risk | +2 | This felt relevant to our scenario, but the rules would be different and an intervention similar to one we had already considered would be needed, which is explained below.<br>Would require accessible OSH information. Lifelong learning to ensure workers are empowered and have the necessary knowledge and skills (technical and social).<br>Governments would need to set up mechanisms to enable effective worker representation so that concerns could be raised and to ensure that they were acted upon. This would need to be both independently and in partnership with business, particularly owners of online work platforms. |
| Proposed by scenario group 2: Automation removing people from dirty, dangerous or hard | +4 | This would happen only if there were a lack of cheap low-skilled labour or the social contract was a very strong driver. Upskilling of workers to increase the wages that they could demand would be needed. A guaranteed citizen's income would also remove the availability of cheap labour. There would still be some exposure due to maintenance or when things went wrong. |
| Proposed by scenario group 3: Licence to work from professional bodies | –5 | Sounds a lot like closed-shop unionism. It was felt that it would damage the new social contract and concerns were raised about who would regulate the professional bodies and how they would do this. |
| Proposed by scenario group 4: Use of wearable devices to monitor stress and exposure to hazardous substances | –2<br>or<br>+2 | It was felt that if organisations had access to individuals' data there would be a privacy issue that would undermine the new social contract.<br>However, if individuals owned the data and were empowered to act upon it, it would be beneficial. Furthermore, it would be also be beneficial if government and organisations |

| Strategies proposed by the other scenario groups | Ranking –5 to +5 | Comments from scenario group 2 |
|---|---|---|
| | | could use the data to spot problems with working conditions as a whole (and fix them), rather than the data being used only to spot problems with specific individuals. |

### *D2.5 Plenary discussion*

The locus of power in society will shift further away from the job-related economy. Traditionally, the most powerful businesses were the biggest employers, so society's interest in good jobs was somewhat aligned with the interests of business. Now those businesses employ relatively few people and their interests will be narrower.

A widespread increase in monitoring of performance, particularly if combined with intensification of work and a reduction in job security, will encourage people to turn to cognitive enhancers, whether chemical (performance-enhancing drugs) or physical (brain implants).

### *D2.6 Comments on the scenarios*

Should the fragmentation result in zero or even negative growth?

Don't forget the opportunities.

Micro-finance could play a key role.

We need to make sure that not all scenarios are written to exclude government from having a role.

The organisational level is missing.

It is not always clear if the scenarios are written on a national basis or a Europe-wide basis.

It would be good to also consider how we could prevent a particular scenario from happening or how we could turn things around to a better situation should we find ourselves in it.

## D3 Results for Scenario 3 — Exploitation

### *D3.1 OSH news headlines in scenario for 2025*

#### Discussion

The group felt that the key factors in this scenario were:

- Uncertainty and insecurity would be stressful for workers.
- It was no surprise that multinational companies had more power in this scenario and that there was increased inequality.
- There was a breakdown of regulation and a failure to regulate labour law and employment contracts. There would also be challenges for labour law and OSH regulation.
- Precariousness would be common in the workforce, with many workers closely supervised and no control of workplace risks.
- There would be a big move towards bogus self-employment and lower social security contributions in this scenario, which would lead to destabilisation.
- Many independent workers would join online work platforms. There would be no government constitution to protect the self-employed in Europe.
- Although most felt this scenario was gloomy, some felt that there were positives, such as people becoming more independent and the fact that individuals would have opportunities in, for example, self-employment. Others thought that micro-economies and micro-communities would emerge to support and advise workers. Someone wondered how bad it would be if governments didn't regulate. They felt that people would be more independent in this scenario, and that some people like or need some kind of 'digital whip'.
- This scenario would result in greater individualisation of work. There would be enormous pressures on individuals to take responsibility for their education, career and OSH. Workers would need to know how to survive in such an environment. How would the OSH community cope with these changes and the extensive psychosocial issues they would bring?
- There would be increases in cases of harassment of workers by an AI peer.
- Could this scenario lead to the reinvention of collective action?

### Headlines

The headlines produced were:

3. 'Workers and robots on strike.'
4. 'Breaking news: AI wins first discrimination case against human workers for harassment.'

## *D3.2 OSH issues in this scenario*

| OSH issue (risk factor) | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| Loss of job content | - AI support takes over much of the job role, workers reduced to a supervisory role<br>- Automation in general (e.g. supermarket checkouts, airport check-in) | All sectors | - Increasing<br>- Lack of job autonomy and control<br>- Increasing, primarily psychosocial risks including stress and boredom. |

| OSH issue (risk factor) | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| | - Primarily psychosocial risks<br>- Monotonous work, decrease in job satisfaction, increase in work-related stress | | - Decreased risk responsibility for workers and the 'irony of automation': work reduced to supervisory role, resulting in de-skilling of workers. This could lead to a potential lack of responsiveness by a worker if something goes wrong, which may result in OSH risks |
| Workers responsible for own OSH<br>Everything becomes OSH<br>'Everything <u>is</u> OSH' | - Individual responsibility for everything related to work and OSH<br>- OSH will mean something else in this scenario, as there is generally no physically defined workplace<br>- With work being carried out anywhere using electronic devices, there will be a need to provide 'working spaces' everywhere (e.g. on trains etc.); this would require a significant change in regulation | All sectors | - Increasing<br>- Primarily knowledge workers, but also remote operation of manufacturing equipment (e.g. in the supply chain for parts manufacture) |
| | - A need for ergonomics to be an important consideration in device design<br>- A need for provision of good OSH guidance and best practices | | |
| Worker capacity to adapt to increasing technological change | - Psychosocial risks<br>- Generally harder for workers (particularly older workers) to adapt to, or be motivated to adapt to, increasing technological change; this may put some workers at risk of exclusion from the workplace | All sectors, but primarily in the most technologically developed sectors | - Increasing |

| OSH issue (risk factor) | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| 24/7 working, blurring of work and home life; work is primarily decentralised | - High psychosocial burden, lack of downtime<br>- Individuals will have a different psychosocial relationship to work compared with the traditional hierarchical model<br>- There may be work pressure for individuals from customers/online platforms or themselves<br>- Mistakes due to fatigue or distraction could result in OSH risks (e.g. crossing the road)<br>- Unknown long-terms effects of 24/7 working and sleep deprivation (some research has suggested burnout can occur); some cancers are associated with shift work — could 24/7 working also have an association with cancer? | Primarily knowledge work | - Increasing |
| Extension of shift work to compete in the global economy | - Link to 24/7 working, potentially with the same OSH challenges<br>- Potential opportunities for social mobility for some | Mainly knowledge work | - Increasing |
| Increase in sedentary work and decrease in manual work | - There will be OSH benefits as a result of large decreases in manual labour (e.g. fewer physical injuries)<br>- There are a number of cardiovascular and other health issues, such as diabetes and blood circulation problems, associated with sedentary work (sitting or standing)<br>- Sedentary workers using ICT extensively may suffer from high levels of cognitive load or sensory overload | Knowledge work | - Increasing |

| OSH issue (risk factor) | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| Virtual environment | - Increasingly, work will be carried out in a virtual environment<br>- Potential health issues associated with work in a virtual environment, such as sensory and cognitive overload, RSIs, eyestrain, MSDs and the effects of sleep deprivation<br>- Psychosocial effects of a lack of interaction between individuals | All sectors | - Increasing/wider<br>- There would be significant challenges for regulators, trainers and designers in relation to virtual work generally<br>- It may be difficult for workers to know how to adapt their work to a virtual environment<br>- There needs to be consideration of how to measure worker satisfaction |
| Multitasking | - OSH challenges: stress of too many things to do and insufficient design or direction of work<br>- Individuals may be exposed to a number of risks at the same time<br>- Potential increased risk of making a dangerous error, depending on the task/job<br>- There will be large amounts of fragmented work and associated online work platforms<br>- OSH opportunities may include the chance to learn new skills and a low risk of boredom, owing to varied tasks/jobs. | Online platform workers | - Increasing<br>- Workers need to be in good mental and physical shape to be able to cope with multitasking; many workers will be unable to cope with multitasking in this scenario |
| Job dictated by AI system or robot that who directs, monitors and assesses work | - OSH challenges may include pressure to perform, loss of or poor job content, resulting in decreased job satisfaction; AI/robots will be focused on productivity, rather than being empathetic to workers, which may result in overwork and could result in psychosocial issues<br>- How much control of workers should AI/robots have? | Any sector where workers interact with AI or robots | - Increasing |

| OSH issue (risk factor) | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| | - How could we integrate human relations and arrange hierarchies of control?<br>- Owing to increased automation of work activities, there will be a reduction in physical risks to workers | | |
| Re-emergence of 'old' OSH risks due to the 'rise of analogue'. | - Human resistance to being dependent on digital<br>- This counter-movement arises from a nostalgia for a time before most things became digital, a backlash against digital and a desire for more 'real' things; for example, the service sector might advertise along the lines of 'Come to us, we have humans' (however, these services would be limited to the wealthy)<br>- The rise of more traditional industries and associated 'old' jobs, may result in the re-emergence of OSH risks associated with these industries (e.g. exposure to wood dust) | All sectors | - Increasing |

- The group felt that there was a duality present in this scenario: a lack of certainty coupled with a lack of human interaction, which is stressful for people. There is also a tension between uncertainty and opportunities.
- In this scenario, it was felt, ways of learning and thinking will be totally changed from today. The lack of central investment will probably lead to a large growth in self-education, self-monitoring and self-health surveillance and -treatment (this can be very dangerous). Individuals can learn knowledge, but not social skills and interactions, meaning that some may be unable to interact effectively with others at work. The group wondered how the quality of MOOCs for online career, job and OSH education could be guaranteed. Accreditation was suggested as a possible solution. There would be opportunities for OSH regulators and trade unions to provide applications and training online in these areas.
- In this scenario, there is a shift from physical risks to psychosocial risks as job roles are increasingly dehumanised.

- In terms of online platform work, there were questions over who is the employer (and who is responsible for workers' OSH)? These platforms are unregulated and are just an online portal for work.
- Some of the group thought that workers would self-organise into sectoral communities or professions to replace the lack of government OSH oversight. Some individuals would be paid to do this job. Could some of these communities be good while others were bad?
- It was felt that competition law would not be enforced in this scenario.
- Knowledge workers will commonly work shifts to compete with the global economy.

New types of job

Potential new jobs in this scenario that were suggested include:

- *Complexity manager*: with the widespread use of wearables, IoT, VR, AR and 5G networks in work, digital coaches will be in demand to help individuals manage the complexity.
- *AI knowledge broker*: it will be important to understand how to train the AI software and ask it the right questions in order to manage and validate the AI's actions, particularly where the AI directs people. In some areas, AI will do some of the work (e.g. medical diagnosis), but a human will do the face-to-face work (e.g. in a hospital). There is a risk that the technical expertise of workers will be lost, which may result in poor OSH outcomes.
- *Data management*: with the advent of the IoT, vast amounts of data will be produced, so there will be a need for more data management jobs.
- *Data analysts*: these jobs will be needed in the short term, before AI systems start to take over the role.
- *Cyber-security*: many jobs will be needed in this area to combat the regular cyber-attacks on business, individuals, government and infrastructure.
- *Elderly person's assistant*: the elite will pay for this service.
- *Face-to-face jobs*: these will be increasingly in demand as a premium service for those who can afford it; everyone else will deal primarily with AI chatbots and systems.

Manufacturing

- Manufacturing will become mostly digitalised and decentralised, with increasing sub-contracting. 3D printing will be a significant part of manufacturing.
- Manufacturing will be closer to the market and will include significant amounts of bespoke, client-driven, short-production manufacture.
- There will be an ongoing increase in the numbers of cobots in workplaces, but the group wondered what the effect on workers might be.
    - What might it mean for teamwork; would the cobot adapt to the human or would the human have to adapt to the cobot? What would the effect be on an individual working alongside a cobot? Might it put performance pressures on workers and cause stress?
    - Sensors on the cobots should help maintain physical safety for human workers, but if the sensors fail, become dirty, or suffer from electrical interference or cyber-attack, the safety systems may fail and there may be the risk of collision injuries to workers.
- Legislation will be required to force industries to digitalise, but this would take a long time. Therefore, social partner agreements would be needed;

these would take months to set up, compared with years for legislation. However, social partner agreements can't happen if there is an online platform economy.

Service sector

- There will be a general de-skilling of work in the service sector due to automation of many job activities, with work being more passive (e.g. automated baggage check-in). As a result of lower job quality, many workers become increasingly demotivated and bored.
- There will be a general lowering of working standards as Europe competes in a global economy against smaller economies that have lower costs.
- There are big issues for OSH in a 24/7 global economy, as working time directives are no longer followed (e.g. lawyers work shifts).

Distributive trades

- There will be fewer long-distance journeys, but lots more local delivery including some by autonomous vans.
- Most people buy things online rather than in store; this drives a large increase in e-commerce and subsequently a big rise in local deliveries.
- Many delivery operatives/drivers are under pressure to deliver as many parcels as they can in a shift. As a result, there are significant stress, fatigue and ergonomic risks to workers (who have to handle a range of different sizes and weights of parcels).

Self-regulation

- The group felt that it was surprising that deregulation would lead to a very strong push for individual self-regulation in this scenario. However, self-regulation itself would need central regulation (through government, professions or insurance); for example, governments could play a background role by ruling that people cannot be active on the labour market unless they are licensed to be so. Alternatively, insurance could be made obligatory for those who wish to work or professions could regulate themselves.

## *D3.3 OSH policies and actions to achieve the best OSH outcome in this scenario*

| Description of action/policy | Expected OSH benefits | Implementation |
|---|---|---|
| **Opportunity**<br>Self-responsibility for OSH | Equipping individual workers with the tools to manage their own OSH effectively | - There is a need to stimulate individual self-regulation somehow.<br>- Workplace OSH would be regulated primarily through regulated professions and self-regulation. OSH regulation and guidance would be done through professional communities (e.g. a 3D printing SME would need a licence and also have to be educated in the relevant OSH regulation/guidance for that profession).<br>- New partnerships of professions and social partners will emerge, which will provide OSH best practices and tools to workers, so that they can manage their own OSH.<br>- Online platform workers will need to be responsible for their own OSH, but would enabling self-regulation be the responsibility of the online platform or the employer? Governments could provide regulation here, for example by requiring online platform workers to have insurance to be able to work. |
| | | - Governments would need to provide an overarching framework for individual self-regulation of OSH. The risks and benefits of self-regulation of OSH are already known; this knowledge needs to be extended to a wider range of jobs.<br><u>Questions</u><br>- In terms of online platform work, how would enforcement be carried out? Would professions self-enforce? |

| Description of action/policy | Expected OSH benefits | Implementation |
|---|---|---|
| | | - If an individual working through an online platform developed a work-related illness, it would not be clear where the exposure was occurring. Who would provide a safety and health reporting system? |
| **Challenge**<br>Decentralised and 24/7 working | | - Implementation through the same methods as described above. |
| **Surprising/novel**<br>Loss of job content | Self-responsibility for OSH results in more individualisation of regulation. More red tape needed, leading to reregulation. | - A requirement that, say, 20 % of time on a job would need to be spent **actually** carrying out real activities rather than just overseeing automation of activities.<br>- A basic income for every citizen. However, if many more people carry out charity work, who is responsible for an individual's OSH?<br>- Companies that use robots could be taxed. |

## D3.4 Wind tunnelling of policies and actions from other scenarios

| Strategies proposed by the other scenario groups | Ranking –5 to +5 | Comments from scenario group 3 |
|---|---|---|
| Proposed by scenario group 4: Programme to increase self-reliance | +2.5 | Similar to one of this group's policies, 'Self-responsibility for OSH'. However, applying this policy in Scenario 3, there would be no guarantee that there would be OSH compliance. In Scenario 3, professional bodies will be stronger (with the policy described by the Scenario 2 group), because of greater technological advances and solutions, and a strong economy. This policy works reasonably well in Scenario 3. |
| Proposed by scenario group 1: Self-supporting micro-communities of interest | +3 | Geographical micro-communities of interest could exist within the professional bodies described in the Scenario 3 policy ideas. However, this policy would not work that well in Scenario 3, as this scenario still has large companies. In Scenario 3, our policies would need to focus on the professional bodies. |
| Proposed by scenario group 2: Increasing automation and basic income | +4 | We could afford to carry out this policy in Scenario 3, owing to a strong economy and accelerating technological advances. The group was not sure that a basic income policy would be supported in Scenario 3. |
| Proposed by scenario group 4: Government encourages employees to do their own health monitoring | +1.5 | There would be increased health (and other) monitoring in Scenario 3, but primarily for productivity reasons. In Scenario 3, the group did not think that employers would listen to the government. The professional bodies could take over the role of encouraging employees to do their own health monitoring in Scenario 3. |

## D3.5 Plenary discussion

Scenario 4 policy: Programme to increase self-reliance

- This policy works well in Scenario 1; the group gave it a score of +5, and thought that it could be paid for by micro-payments (e.g. Bitcoin).
- In Scenario 2 the group felt that this policy would work quite well, and they gave it a score of +3. The Scenario 2 group thought that this policy would have government support and social funding, but that occupational health providers would still be needed.

Scenario 1 policy: Self-supporting micro-communities of interest

This includes micro-communities created by local government.

- Comments from the Scenario 1 group indicated that they felt that this policy would be good for OSH, as it would help people build autonomy and

increase their well-being, engage individuals on a social level and improve innovation.

- There would be a need to find ways to encourage networking and work together with other OSH actors to make these communities accessible to all. There is a key role for trade unions and worker associations here.
- There is a need to maximise use of technology to make the micro-community system effective.

Scenario 2 policy: Increasing automation and basic income

- The Scenario 2 group felt that this policy would improve OSH by removing people from harmful jobs. This would be a government-led initiative.
- In addition, they felt that, because of a new social contract, workers displaced by automation would be upskilled. There would also be a guaranteed citizen's income.
- The Scenario 3 group raised the complication of the OSH of individuals doing unpaid work (e.g. voluntary work).

## *D3.6 Comments on the scenarios*

General comments on all scenarios

- The biggest drivers in the scenarios are high or low economic growth (linked to technological development).
- Government does not appear to have too much of a role; one participant said that the scenarios were written in a way that minimises the role of government too much, which limited the choice of interesting policy solutions. John Reynolds replied that in Scenarios 1 and 2 there is a strong government. In Scenario 2, the government can keep pace with change, whereas in Scenario 1 it has limited money.
- Another participant suggested that we could think about how to prevent these scenarios occurring. John Reynolds replied that this would involve carrying out a risk analysis exercise.
- There was a comment that the organisational level (e.g. how we design work processes, management systems, etc.) was somewhat under-represented in the scenarios.
- Someone would have liked to have had more information on the wider future environment (e.g. public health).
- Another participant was curious about how this process would perform with real policy decisions and wondered how to ensure enough dialogue and balanced viewpoints to effectively evaluate policies against the scenarios. John Reynolds replied that, to do the full wind tunnelling process, you would spend a lot longer (e.g. a few days) reviewing the policies, with experts with a wide range of experiences, and review the results later.
- One participant thought that it would be good to think about how we could prevent Europe arriving at these dystopian scenarios. John Reynolds replied that you could also use scenarios to carry out risk analysis and risk management to consider what could potentially be done to prevent events happening. However, once an organisation has done work with future scenarios, it is generally more alert to potential emerging pitfalls.

Scenario 2

- Big corporate organisations would need a licence to operate, as they would have access to huge amounts of personal data on their employees. A strong government would be needed to enforce that.

- A strong government would also be needed to broker a compromise and gain a significant level of trust on the part of individuals for them to allow big corporations to have access to large amounts of employee data. These corporations would be required to be open and transparent about what employee data they collected and held and what they did with it, and about what they did with their AI algorithms. A strong government would make sure that corporations did not become too powerful and would also require them to contribute to the social contract and educate individuals from a young age about the social contract. Social partners would be key in this scenario. Overall, this might be hard to achieve and sustain.

Scenario 1

- The government sets the legal framework and laws, but there are not enough funds for effective OSH control. So the government will have to work with other agencies, such as targeted social partners, to get effective OSH information out and to communicate to workers where they can find OSH information. To do this, the government needs to manage its resources carefully.

Scenario 4

- Social dialogue has broken down; however, over time it will re-emerge, enabled by technological solutions.

# D4 Results for Scenario 4: Fragmentation

## *D4.1 OSH news headlines in scenario for 2025*

### Discussion

- Increased need for grey economy workers to look after themselves.
- Social isolation increases as large organisations fragment.
- Ageing population makes issues worse.
- Lower population growth leads to vicious circle, with ageing population.
- More flexible jobs, changing roles and multiple jobs working in more sectors, with less training but a need for a range of skills, and hence increasing risks.
- ICT can still replace workers in some sectors — such as manufacturing or delivery — more easily than in others.
- OSH varies by sector/size/role but is poorer in small companies and in the grey economy.
- In this scenario, there will be fewer inspections and less enforcement, leading to more failures.
- There could be a recycling black market with increased and uncontrolled waste hazards.
- There will be less heavy industry, and an automated food industry.
- Some self-organising communities and networks.
- The government fails to keep up with technology (despite slower change than in the other scenarios), so OSH regulations are not updated and there are no worker representatives.

**New/increasing jobs**

- Emergency response, maintenance.
- Cyber-security advice and supervision (not necessarily good quality).
- Mutual mentoring and support; risk of 'fake news' stories.
- Collaboration coordinator: as more jobs are outsourced and home working increases, advice on how to work together becomes more important.
- Monitoring/surveillance reviewer: AI can do preliminary checks, but, with much increased monitoring, there are a lot of cases that need reviewing.
- Platform economy software developer.

### Headlines

The headlines produced were:

5. 'Disaster at factory caused by failure to apply health and safety policies.'
6. 'Cyber-attack takes down welfare systems.'
7. 'Social media company accused of selling personal data to retailers.'
8. 'Elderly exploited by gig economy.'

## *D4.2 OSH issues in this scenario*

| OSH issue | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| Managing OSH in self-employed, home working and grey economy situations | **Challenge**<br>Not possible to track or monitor decentralised work; enforcement fails. | Gig economy, management, admin, IT | Lots of low-level risks such as poor posture, RSIs, stress; increased risk of falls in construction and maintenance areas. Risk already exists but grows rapidly in this scenario.<br>Lack of support from trade unions or other collective approaches.<br>Increased financial and psychosocial stress in the gig/grey economy as more precarious employment makes financial planning difficult and social isolation increases. |

| OSH issue | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| Increased fragmentation of supply chain | **Challenge**<br>Harder to identify responsibility for OSH. | All | Tendency for sub-contractors to cut corners to reduce costs. Lack of pre-emptive OSH management — only reactive contract violation measures. |
| Use of technology in traditional industries | **Opportunity**<br>Even in Scenario 4, some traditional manufacturing continues. So there is an opportunity to apply monitoring technology and expert systems to reduce exposure to hazards, track stress and general health. | Mainly manufacturing, retail | Monitoring also brings privacy and data protection challenges in this scenario. Debate over who owns the data, as in the confidentiality dilemmas of a company doctor. |
| Multiple jobs | **Challenge**<br>Frequently changing of jobs means a lack of understanding of different risks, and less experience. | Various | A need for increased training — which is not readily funded in this scenario. Fewer experienced colleagues to learn from. |
| Self-reliance | **Opportunity**<br>Individuals use monitoring technology and increase their awareness of risks because they need to avoid being ill and not earning. We already use the internet to look for health information and for advice on self-treatment, so new sources of advice online could be used to improve OSH for those outside larger organisations. | Grey economy | An optimistic view. Could also bring greater contentment and self-realisation for those whose personal style is more autonomous. There was some concern that encouraging self-reliance would also encourage the grey economy, and that it would be better to resist it. |
| Reduction in enforcement operations | **Challenge**<br>Lack of funding reduces OSH agencies' ability to proactively assess work environments. Government boasts of cutting red tape with fewer safety inspections. | All | Already happening to some extent. |

| OSH issue | Describe: OSH challenge or opportunity | Sector(s) of the economy | Comments (new or increasing, who is most affected, nature of impacts, etc.) |
|---|---|---|---|
| Increased mutual support through social media | **Opportunity**<br>The informal economy provides opportunities for peer-to-peer support. | | Patchy and poorly structured. |
| AI algorithmic bias | **Challenge**<br>Increasing discrimination and unjust decision-making. | Professions | Less development of advanced AI means that systems may be less robust and less well tested. |

There was a feeling that in this scenario there could be a backlash against the prevailing ideology — a 'cyber-rebellion' aimed at taking down the elite with widespread hacking: 'cyber-Anonymous'. This could happen if the young generations got frustrated by the rule of algorithms, loss of privacy, injustice, etc., and used their IT skills to hack systems and overturn the elite. Even if not successful, this could be very disruptive, bringing risks of system failures.

Sectors affected are mainly professionals, administration and support, plus distributive trades and ICT, which are most affected by the gig economy. In manufacturing, there will be more automation (although not as much as in some other scenarios), which reduces exposure to hazardous environments. Healthcare becomes polarised, with more care at home but with care workers closely monitored.

Generally:

- there are more unknown hazards and surprises, with only a reactive approach from government;
- there is less OSH management;
- contractual arrangements delegate OSH responsibility without control;
- the role of the labour inspectorate and that of risk assessment come under threat; is risk assessment even feasible in the grey/gig economy?

## *D4.3 OSH policies and actions to achieve the best OSH outcome in this scenario*

| Description of action/policy | Expected OSH benefits | Implementation |
|---|---|---|
| **Opportunity**<br>Build self-reliance to encourage better OSH among self-employed, multi-job workers and workers in the grey economy | Reduced accidents and adverse health effects in small companies (e.g. with regard to poor posture, RSIs, falls) | **Government:** education and awareness, starting in schools; show economic effects of avoiding harm; stimulate incident-sharing communities; tax rebates or penalties for compliance/non-compliance |

| Description of action/policy | Expected OSH benefits | Implementation |
|---|---|---|
| | Reduced stress caused by loss of earnings while off sick; improved sense of personal control and autonomy | **Insurance industry:** reduced premiums if you can demonstrate compliance<br><br>**Entrepreneurs:** developing online support services (extensions of today's health websites), although there is a challenge around managing/checking the quality of these services |
| **Challenge**<br><br>Avoiding downsides of health monitoring in remaining larger organisations<br><br>- Privacy<br>- Surveillance<br>- Discrimination | Maximise benefits of health monitoring for stress and other conditions | **Government:** encourage employers to see that OSH means improved profitability; set clear rules on data ownership; sharing information at industry level so that norms can be established |
| **Surprising/novel**<br><br>Use medical practitioners to encourage preventive attitudes to OSH, as in other preventive medicine approaches | Fewer incidents | **Government:** part of the self-reliance campaign; GP education required (GPs might need more pay, which would be a problem in this scenario) |

The group also discussed ways of reducing AI algorithmic bias, which in this scenario is a greater risk because of lower investment and older AI. The view was that government should make AI system designers clearly responsible.

Overall, there is a more precarious employment pattern for professionals and manual workers alike, which brings increased inequality and a 'dog eat dog' attitude. People working in larger organisations are monitored and controlled more closely. Some people in the grey economy relish the lack of restrictions and government intervention and take pride in 'looking out for themselves'. Policies that support this attitude, while still emphasising OSH, offer the prospect of reducing the risks.

## *D4.4 Wind tunnelling of policies and actions from other scenarios*

| Strategies proposed by the other scenario groups | Ranking –5 to +5 | Comments from scenario group 4 |
|---|---|---|
| Proposed by scenario group 4: Self-reliance | +5 | To address problems of managing OSH among self-employed workers and grey economy workers: the only way forward as government enforcement wanes and OSH responsibility becomes dispersed or unclear. |
| Proposed by scenario group 1: Micro-communities | 0 | In principle, it seems OK and chimes with self-reliance. However, it relies on social cohesion, which is low in Scenario 4, with no or weak trade unions. There may be some local pockets of success in a 'bottom-up' way, but, in general, lacking funds, government is likely to see this as a waste of money and not actively support it. Entrepreneurs may push 'self-help' advice (online and offline), but this won't be a coherent, structured approach. |
| Proposed by scenario group 2: Automating work in hazardous environments | –5 | Nice idea, but this will be very limited in Scenario 4, where a citizen's income is unaffordable and investment in technology is low. Government would want to keep as much traditional industry as possible and avoid throwing even more people into the grey economy. This could develop if a 'good OSH means better profits' attitude were fostered, but this is unlikely. |
| Proposed by scenario group 3: Self-regulating professional bodies | –2 | Again, this policy sounds like it might link to self-reliance, but in Scenario 4 professional bodies are weak and cannot control their industries. It is likely to increase costs, which is unaffordable, and in any case compulsory insurance does not reduce risk; it merely punishes failure. |
| Proposed by scenario group 4: Health monitoring | +4 | Clear benefits for the remaining larger organisations. Implementation may be hampered by data privacy concerns, and the association of monitoring with surveillance and control. |

## D4.5 Plenary discussion

This group felt that the self-reliance strategy should be very effective in most of the scenarios, as centralised control slipped away. It could be seen as 'empowerment' in the two scenarios with active governments, where more proactive support could be provided.

The policy of automating work in hazardous environments could be made more viable in Scenario 4 (and others) if the concept of a citizen's income were removed. There is a clear incentive for employers to reduce the costs of worker protection in such cases.

The policy of self-regulating professional bodies seemed very interventionist, and we would expect it to work only with active government support.

Encouraging/educating general medical practitioners to consider OSH among those working at home seemed a simple and natural thing to do in any scenario. It was pointed out, however, that there might be costs associated with this, which could be challenging.

## D4.6 Comments on the scenarios

The group agreed that Scenario 4 was entirely plausible, if very unattractive. Some elements of it could already be seen in the current environment, and sliding into this future needed to be actively avoided. The group was frustrated that the scenario left little room for positive OSH interventions and concerned about the role that labour inspectorates might have. However, it was thought that there would be some backlash against Scenario 4 (after major disasters, perhaps), leading to a future closer to Scenario 1. Other reactions could be the 'cyber-rebellion' mentioned above.

Scenario 1 was also seen as a viable, quite likely, outcome, especially in the more socially cohesive countries in Europe, and assuming a strong/coherent EU. It was interesting to see that Scenario 2, despite initially appearing attractive, still gave rise to many OSH challenges; it was also seen as the least likely outcome. Scenario 3 was perhaps more likely, and positive in terms of growth, but still with many OSH concerns.

There are many common themes, or likely developments that would probably occur in all the scenarios. Some combination of the scenarios is more likely to be the actual outcome.

## D5 Wind tunnelling of policies across all scenarios

Policies were ranked from –5 to +5 where –5 was, in the group's opinion, a policy that would be not at all successful in their scenario and +5 was a policy that would be very successful. The policies that the groups felt would be the most successful in their scenarios are highlighted in red.

| Policy | Scenario 1 Evolution | Scenario 2 Transformation | Scenario 3 Exploitation | Scenario 4 Fragmentation |
|---|---|---|---|---|
| Enhancing self-reliance programme (Scenario 4 policy) | +5 | +3 | +2.5 | +5 |
| Self-supporting micro-communities of interest (Scenario 1 policy) | +5 | +2 | +3 | 0 |
| Increasing automation and basic income (Scenario 2 policy) | –4 | +5 | +4 | –5 |
| Self-responsibility for OSH (Scenario 3 policy) | –5 | –5 | +5 | –2 |
| Government encourages employees to do their own health monitoring (Scenario 4 policy) | +3 | +2 | +1.5 | +4 |

## D6 Individual vote on which scenario was most likely

| Voting | Scenario 1 Evolution | Scenario 2 Transformation | Scenario 3 Exploitation | Scenario 4 Fragmentation |
|---|---|---|---|---|
| Scenario most likely to be reality by 2025 | 8 | 4 | 3 | 6 |

# Appendix E — Key trends and drivers of change

## High impact, high uncertainty trends and drivers

### 1. Virtual and flexible working

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

### 2. Supply chains and distribution

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

### 3. Micro and small enterprises

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

### 4. European Digital Single Market

| | |
|---|---|
| **P1.1** | **The European Digital Single Market** is one of the European Commission's 10 priorities. A Digital Single Market in Europe could create hundreds of thousands of jobs and bring €415 billion to the EU economy each year. |

| | |
|---|---|
| **P1.6** | **Regulation of new working patterns:** many new working patterns are not well served by existing regulations. |
| **P1.7** | **Governance of ICT-ETs:** as use of ICT-ETs has increased, there has been a corresponding increase in demand for the regulation of its use, as well as concerns about inappropriate regulation or over-regulation. |

**5. Economic environment**

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

**6. ICT knowledge and skills**

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

**7. Online environment and attitudes**

| | |
|---|---|
| **S4.2** | **Attitudes to online privacy:** people may be concerned about privacy and security of data, but they may still be willing to share data online because of the convenience it brings. |
| **S4.3** | **Public attitude to (acceptance of and demand for) ICT developments and ethics:** major new developments will be dependent on the acceptability of and demand for the technology, which is dependent on whether or not it is seen as a threat to people's preferred way of life/social model or ethics. |
| **New** | **Technology adoption rates:** time taken for technology to be fully adopted. |
| **S4.5** | **Discrimination, violence and bullying:** facilitated by the rise in the use of ICT-ETs and social networking at work. |

**8. Collective action**

| | |
|---|---|
| **P1.3** | **Security and privacy:** these are two sides of the same coin — as governments believe they need to monitor internet communications more thoroughly to prevent terrorism, the public may begin to become more concerned about its privacy. |
| **S4.4** | **The future of collective action:** there is diversity in union density across the EU; however, the general trend is a fall in trade union membership. New online platforms for collective action may spring up to replace trade unions. |
| **T5.1** | **Social media** is increasingly popular as a tool to enable individuals and businesses to communicate, network and collaborate across the world. |
| **T5.3** | **Open IP movement** ([7]): concern has been expressed that unless Europe moves to an open data model, the digital economy is unlikely to progress. |

## High impact, lower uncertainty trends and drivers

**9. Data and the knowledge economy**

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

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

**10. Workforce demographics**

| | |
|---|---|
| **S1.1** | **Population changes:** while the global population is rising, the EU population is slightly falling and the active workforce is also becoming smaller. |
| **S1.2** | **Ageing workforce:** while the average age in the EU is increasing, there are variations across the EU, and, in general, there is lower average age in candidate countries. |
| **S1.3** | **Increasing migration into EU:** caused by large differences in standard of living between countries and by refugees from conflict, facilitated by mobile devices providing ease of access to information about different countries and travel options. |
| **P1.5** | **Control of migration:** the recent surge in migration from the Middle East and Africa has led to major rethinking of immigration policies across Europe. |
| **S1.4** | **Generational differences:** the increasing length of working life means more generations in the workplace, from 'digital natives' to those who have been working for some time and those who are coming close to retirement age or have already retired, with very differing attitudes to hierarchical organisational structures, sharing information online and using ICT at work. |
| **S1.5** | **More women in the workforce:** women tend to prefer 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, as a result, the need for more inclusive and adapted workplaces, an increase in incentives at policy level and awareness-raising initiatives. |

**11. Built-in OSH**

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

## Key technologies

**12. Robotics, autonomy and artificial intelligence**

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

| | |
|---|---|
| **T2.8** | **Drones:** their use for work purposes is expanding rapidly and this is expected to continue in the future. |

**13. The internet and big data**

| | |
|---|---|
| **T1.5** | **Internet of Things:** there is potential for vast numbers of cheap sensors taking measurements to open up a wealth of possibilities for machine-to-machine (M2M) communication and pervasive sensors, especially when combined with big data analytics and machine learning. |
| **T1.6** | **Big data** is a combination of three trends: increasing rate of data generation; improving data storage; and advancing data analysis. |
| **T2.5** | **Industry 4.0:** the 'Internet of Things' and M2M communication are enabling an emerging trend towards lights out manufacturing (manufacturing without human involvement). |
| **New** | **Transparency of algorithms:** making the algorithmic structures of autonomous systems or AI clear and accessible. |

**14. Cyber-security**

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

**15. Virtual and augmented reality**

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

**16. Communications networks**

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

**17. Human interfaces**

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

### Trends considered to be outcomes rather than key drivers

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

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

### Wildcards

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

| | |
|---|---|
| **P2.1** | **Terrorism and war:** terrorist attacks in European capitals cause a reduction in travel and 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, there could be a noticeable effect on patterns of behaviour. |
| **P2.2** | **Increasing geopolitical volatility:** the geopolitical landscape is currently constantly and rapidly changing. |

# Appendix F - Cross-scenario analysis of key drivers and uncertainties

As part of the base scenario development, a cross-scenario impact analysis (as mentioned in Section 2.4.4) was carried out to capture and compare the features of each scenario in terms of all the key trends and drivers for each axis (see Tables 1 and 2) and the impacts of ICT-ETs in each scenario (see Table 3). This allows the differences and similarities under the scenarios to be easily seen in relation to the key trends and drivers. It is based on the discussion of the scenarios during workshop WS2-1 and the data from the horizon scanning in Work Package One.

**Table 3: Cross-scenario impact analysis for Axis 1 — Governance and public/workers' attitudes**

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| **Governance** | | | | |
| The European Digital Single Market (DSM) | Strong support for the DSM, but slow progress owing to a lack of structural investment. | Strong support for the EU and recognition of its authority to develop the DSM, with good progress being made. | Moderate progress being made owing to interest from business. | Little or no progress owing to lack of investment and of political will. |
| Governance of ICT-ETs | Moderate level of regulation that generally keeps up with changing technology, e.g. via (non-systematic) incentives. Significant change in regulation is not necessary yet because of the slow pace of technology. | Governance is based on trust, driven by social norms, goal-based rather than prescriptive, consensual and participatory. Regulators act as coordinators, which generally enables them to keep pace with rapid developments in technology. The desire to reach a consensus can, however, slow down the application of new technology. | Lack of government engagement or resources means that regulation cannot keep up with technological changes. | Minimal regulation — 'cutting red tape'; large, unregulated grey economy. |
| Regulation of new working patterns | Governments are generally effective in the regulation of new working patterns and in accommodating social norms and values. | New working patterns are adequately regulated. This is most often through social norms, collective values and company values, rather than legislation. | No real regulation of new working patterns; the economy is dominated by the gig economy and zero-hours contracts. | Minimal regulation of new working patterns — 'cutting red tape'; large grey economy of workers who avoid regulation. |

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| | | AI monitoring via wearable technology also encourages good working practice.<br>New working patterns are reviewed by social partners before being allowed. | | |
| Changes in HR management | Governments have retained an emphasis on the protection of workers' rights, and this is reflected in HR management. This is not heavily regulated but based on personal and company values and the desire to be a good employer. | Less 'in person' interaction at work. HR management is carried out by AI systems that often remotely monitor stress, promote well-being and encourage safer work practices. The consensual approach leads to continual adjustment and AI continuously learns to accommodate the needs of all social partners. | HR management is predominately carried out by AI systems that remotely monitor performance and productivity. | Less formal HR management, focused on hiring and firing, and flexible contracts. Less focus on OSH systems. |
| Open intellectual property (IP) movement | IP is protected across the EU as a protectionist measure. Some local sharing within groups of people who form their own communities of interest and cooperative micro-economies. Some IP is, therefore, unevenly distributed as these mechanisms are uncontrolled. | IP is commonly shared, but its economic value and that of data are recognised. This balance promotes economic growth and minimises the probability of data loss or misuse. | Massive open online courses (MOOCs) are widely available. IP is strongly protected by large corporations. However, some IP is shared within worker online collectives and IP is sometimes shared by small start-up companies to help speed up their product development. | The open IP movement has stalled — proprietary systems dominate in the search for quick profit. |

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| | | | | |
| **Public/workers' attitudes** | | | | |
| The future of collective action | Employees, workers' representatives, business leaders and governments work together through social dialogue to seek to maintain a consensus on the exploitation of ICT-ETs at work. | Successful trade unions work collaboratively through social dialogue and closely with online work associations. Those that do not cease to exist. | Trade unions, governments, employees and business leaders have failed to work together to reach an agreement on ICT-ETs and work. The number of trade unions has significantly reduced, their influence is generally low and membership is dwindling. However, there are a few online collectives (guilds) that are succeeding in protecting certain sectors and groups of workers. | Collective action continues through traditional trade unions. However, their influence and membership are diminishing as a result of an increasingly diffuse workforce. |
| Social media | Used to share best practices on OSH issues and 'name and shame' those who abuse the regulations or workers. The quality of information is subject to audit and is generally good. | Used by workers and worker/job associations to share knowledge and assets, form teams, and for continuous professional development. Open processes exist to ensure the high quality of the information provided. | Workers increasingly use social media to form collectives to try and improve their working conditions. Social unrest is common, organised via social media. | Used to share best practices on OSH issues. However, the information is sometimes not trusted and is challenged based on opinion rather than facts.<br>Also used to support the grey economy. |

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| Security and privacy | Governments have been slow to counter cyber-crime and terrorism threats, reducing confidence in investing in cutting-edge technology. Implementation of systematic security policies is frustrated by ad hoc slow development of technology. | There is a well-funded, coordinated response to cyber-threats. This includes investment in a highly secure robust online infrastructure, which has allowed the development of a large variety of new apps and smart connected technology. Workers are generally monitored by wearables and AI systems that measure levels of stress, promote well-being and encourage safer work practices. Some, however, are concerned how much they are monitored. | Increasing frequency of cyber-attacks due to a lack of investment or a coordinated response to the threat from governments and corporations. Most workers are monitored online and via wearables while working. Workers' leisure time is also monitored. | A vicious circle of low investment in maintenance leading to increased failures, greater numbers of cyber-attacks and consequently even greater loss of public trust.<br>Increased monitoring and surveillance has led to loss of privacy. |
| Attitudes to online privacy and ethics | The exploitation of technology is constrained by regulation owing to the need to respect the widespread concerns about protecting individuals' privacy and to be seen to be acting ethically. Low-impact measures are adequate because of existing social values and trust. | Attitudes are, on the whole, positive, as ethics and online privacy and data protection regulation and technology have all evolved to keep pace with the challenges of rapid technological change. | A generally low level of ethics. Privacy is disregarded by corporations; focus is on performance and productivity, and regulation is weak. | A lack of resources and acknowledgement of public concerns has led to weak regulation and low public trust. |
| Discrimination and violence and bullying | These are not tolerated in the workplace. Low-impact measures are adequate because of existing social values and trust. | Not acceptable as part of generally recognised working practices. Online platforms, using AI, are designed to identify and prevent these problems. | Common in the workplace owing to the highly competitive business environment and the difficulty for regulators of keeping up with the fast pace of change. | Can occur in the workplace as a result of gaps in regulation and low profit margins for many businesses. Intensive monitoring provides opportunities for management bullying. |

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| Technology demand and adoption rates | There has been a public debate on the acceptance of and demand for ICT-ETs. Governments' lack of action in recognising cyber-crime and terrorism threats, of investment in education and of transparent communication have delayed and constrained adoption. | Ongoing, moderately rapid technological change, moderately high levels of adoption and exploitation of ICT-ETs. | Ongoing, rapid advances in ICT-ETs. Technology exploitation is maximised in areas that yield the best economic return. | Entrepreneurs exploit opportunities inherent in existing technology, but few new major innovations emerge. |
| Inequality and polarisation | Inequality has widened and there is the prospect of gradual loss of middle-income jobs and a general decline in standards of living, with the younger generations facing worsening prospects. There are still quite a lot of people whose talents are not used. They are involuntarily unemployed, although they receive a supported income, e.g. a base income. | Low levels of inequality owing to a technology-facilitated matching of individuals' skills and wishes with company needs. Moreover, the benefits of ICT-ETs and high growth are widespread across sectors and the countries of Europe.<br>There is a small underclass of people on the outside of society, through their own choice. They are socially respected in their choice, and financially supported. | High levels of inequality with a hollowing out of the workforce due to the loss of middle income jobs. | Significant inequality and a precarious workforce with a general decline in standards of living, with the younger generations facing worsening prospects. |

**Table 4: Cross-scenario impact analysis for Axis 2 — Economic growth and the application of technology**

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| **Economic growth and investment** | | | | |
| EU growth | A decade of low growth, averaging about 1 % per annum across the EU. | High economic growth throughout the decade, with growth now consistently at over 3 % each year. | GDP growth is relatively low at the start of the decade, but rises to an average of 3 % per | GDP growth throughout the period remains low, at 1 % per annum at best. |

| Key trend/driver | Scenario 1 EVOLUTION | Scenario 2 TRANSFORMATION | Scenario 3 EXPLOITATION | Scenario 4 FRAGMENTATION |
|---|---|---|---|---|
| | | | annum across the EU by 2025. | |
| Availability of investment funding | Low government investment in building the physical and research infrastructure required to support new technologies. | Ongoing joint investment by governments and corporations. | Investment by businesses in research and development (R&D) for ICT-ETs that maximise profit. Little government investment in R&D. | Investment by both business and government in infrastructure and R&D is very low. |
| Investment in education and employment initiatives | Investment in new skills is patchy, left mainly to the big corporations, or to motivated individuals or local initiatives.<br>Politicians across Europe have chosen to seek electoral success through employment initiatives aimed at protecting existing traditional jobs. | Ongoing joint investment in education, training and employment initiatives that make good use of ICT-ETs are available to all, leading to a culture of lifelong learning. | Large corporations invest in ICT skills where there is an immediate need or the skills cannot be purchased. Little government investment in skills or education. | Investment in new skills development is very low — skills development is left to the individual. |
| Changes in levels of globalisation | Loss of confidence in international trade; Europe seeks to protect its economies with a 'Fortress Europe' trade policy.<br>Global corporations continue to invest — but do so in the context of their own business strategies. | Significant investment in overseas development to develop markets and mitigate high levels of migration into Europe. | Global corporations invest in their own economic interests.<br>Large corporations use offshoring increasingly less owing to high and increasing levels of automation and additive manufacturing. However, a significant proportion of knowledge-based work is sourced through online platforms and is therefore international. | Global companies balance offshoring with automation, with a focus on reducing costs. |

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| Tax planning and avoidance | Governments' focus on social protection (doing what voters want, rather than what they need) leads to inefficient and ineffective fiscal regimes — taxing the wrong things. | An innovative taxation system taxes robots and intangible assets. Tax avoidance is uncommon and socially unacceptable. | There is a lack of regulatory frameworks to effectively tax businesses. Therefore, global corporations exploit any opportunity to avoid tax. | Tax avoidance is endemic, both in business and by individuals. Avoiding tax is seen as 'smart', or at least sensible. |
| **The application of developments in ICT-ETs** | | | | |
| How the demand for and adoption of technology will evolve | Technology exploitation has been slow. ICT investment is/has been focused on areas where costs are lower or where profits are highest.<br>Some scattered technology improvements result from ad hoc incentives. | Ongoing, moderately rapid technological change. ICT-ETs are exploited fully and distributed widely across sectors and the countries of Europe. | Rapid technological advancements. Technology exploitation is quick and focused on areas where costs can be reduced. | Technology exploitation is focused on areas where costs can be reduced. |
| **Impact on the nature and locations of work** | | | | |
| Virtual workplaces | There has been a growth in virtual workplaces, initiated by individuals and trusted, uncontrolled collaboration (e.g. via Facebook and LinkedIn). | Intensive, virtual working is common, comfortably facilitated by technology and styles of working within a trusted working culture. | The economy is dominated by freelancing, short-term contracts and the gig economy; virtual workplaces are used to bring globally distributed workers together. | There has been a growth in virtual workplaces as business transfers costs to individuals. This applies to technology too, as workers are often required to buy or bring their own ICT devices. |
| Flexible working patterns | Slow change is the norm across most of the economy, except in big corporations, and in local exceptions where either worker communities of interest or local entrepreneurs drive innovative practices. | Most individuals work highly flexible working patterns, often for several employers at a time. Work is often intense, 24/7 and can take place anywhere. | Most work is of a flexible nature; long-term careers are a thing of the past. | Much work is of a flexible nature — a gig economy with workers on zero-hours contracts or nominally self-employed and no one having a long-term career. |

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| | There is uncontrolled flexible working, often for many assignments/ employers, which can lead to unwanted peaks and troughs in the amount of work and a consequently uncertain income. | However, this is controlled for optimal performance and well-being by monitoring technology. Most people are able to take breaks between contracts for continuous professional development and leisure purposes. | | |
| Crowd-working | This has been limited to mostly small-scale local crowd-working initiatives, owing to a lack of support for infrastructure investment. | Crowd-working is common and usually done via online corporations and worker/job associations that assemble multidisciplinary teams. This is enabled by market and personal talent connecting technology. | Crowd-working is used extensively, where necessary, to reduce costs. | Crowd-working is used to drive down costs — work goes to the cheapest bidder, regardless of quality. |
| Gaps in ICT skills | 'Brain drain', as talented (often young) people move to faster-developing economies.<br>MOOCs and other online portals offer the prospect of making up some of the gap in technological skills and knowledge. | Good ICT skills are widespread throughout Europe and across generations. Interactive high-quality MOOCs, (often accredited or funded by online employment associations) are available to all. | At the start of the decade, there was a general lack of ICT skills among older workers. Over time, businesses have increasingly invested in ICT skills related to areas of business demand, so the skills gap has reduced. This investment and MOOCs bring some opportunities for the lower-skilled. | There are still some high-skilled people making exploitative profits, but generally de-skilling is more common. Younger people generally have better ICT skills than older people. |
| Quickening pace of knowledge transfer | The pace of knowledge transfer has risen steadily, facilitated by positive public attitudes to the use of ICT for this purpose. | Individuals collaborating within and across disciplines, big data, | Individuals are cautious of sharing knowledge and businesses guard their IP. | There is generally a very low pace of knowledge transfer. However, those with high-status roles share |

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
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| | However, this occurs much more easily in urban than in rural areas owing to ongoing limitations on access to high-speed broadband.<br>New technology development is mainly driven by large corporations. | AI and the sharing of IP means that knowledge is transferred quickly and technological innovations are rapid. | Development of new technology is done mostly by large corporations, with a small contribution from small enterprises, which sometimes share IP for mutual business benefit. | knowledge more freely. |
| More frequent and bigger shifts in the skills required for work | Under-investment in new technology means that the rate of change in the labour market has been relatively low — only 10 % of jobs have disappeared, but about 40 % have been moderately changed by support from new technology. Generally, there has been a moderate increase in the skills required for work. | The rate of change in the labour market has been relatively high — around 50 % of jobs have been fundamentally changed over the last decade, of which about one quarter have been either lost or automated. However, most individuals have good ICT skills and undertake continuous professional development to successfully keep their skills up to date with the rapid changes in ICT-ETs. | The rate of change in the labour market has been relatively high — around 60 % of jobs have been fundamentally changed or lost; of these 40 % have been lost. Good jobs require a high level of ICT skills, e.g. for programming jobs, but most jobs require a good level of ICT skills and these skills need updating regularly to keep pace with rapid technological developments. | Around 20 % of current jobs have been lost, mainly to automation of low-skilled, repetitive work. This has led to the loss of manual jobs first and then other, clerical jobs. Few new (formal) jobs have been created. Many jobs that remain require a high level of ICT and other skills.<br>Most people will change jobs frequently as they are pushed out or see new, temporary opportunities. |
| Offshoring and reshoring | Major corporations are happy to offshore services and manufacturing (and profits), where they can. | Very low levels of offshoring. Most manufacturing is now done locally using ‘lights out’ or additive manufacturing. | Levels of offshoring are generally diminishing owing to the potential to reduce costs through automation and local additive manufacturing. However, knowledge-based work is frequently offshored to the cheapest bidder via online platforms. | Whether work is offshored or not depends on the relative costs of offshore labour and automation locally. |

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| **Changes to business structures** | | | | |
| Micro, small and medium-sized enterprises | Low growth makes it hard for small and medium-sized enterprises (SMEs) to invest in new technology.<br>Some people have taken joint action to protect themselves and foster local micro-economies, but this is the exception rather than the rule. | Ongoing rise in small start-ups and SMEs, facilitated by government policies. | Large global organisations remain, but micro-enterprises and SMEs are increasingly supplying products locally. | Larger, older organisations dominate, with fewer SMEs and entrepreneurs, as there is little scope for experiment or innovation. |
| Rise of the entrepreneur | Entrepreneurship has been constrained, as there has been a desire to protect existing jobs and businesses have looked to survive and build a more secure future. | Increasing numbers of entrepreneurs, facilitated by government policies. | Limited entrepreneurship, predominately by small start-up companies, where technology reduces the cost of entering sectors of the economy. | There is nominal self-employment in the gig economy. |
| Sub-contracting | Unemployment has remained high. There is a demand to protect jobs and wages have been constrained over the last decade, so there is little pressure to sub-contract. | There are high levels of sub-contracting; most individuals carry out several contracts for a number of employers at any one time. | There are high levels of sub-contracting to reduce costs; most people work for more than one employer at any one time. | Significant levels of sub-contracting take place on a flexible and precarious basis, to reduce costs and avoid regulation |
| Increase in e-commerce | The rate of growth has been constrained by cyber-crime. | High levels of e-commerce, which have risen in line with increases in GDP growth. Cyber-crime affects e-commerce operations occasionally. | Levels of e-commerce have continued to grow in line with increases in GDP growth. Cyber-crime affects e-commerce operations periodically. | The rate of growth has been constrained by cyber-crime and lack of innovation. |

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| Alternative distribution chains and manufacturing | Support for 'traditional businesses' and increased trade protectionism has meant that there has been low investment in innovation. | Most manufacturing activities have been automated. Additive manufacturing has disrupted and continues to disrupt existing distribution and supply chains. | Manufacturing is now almost entirely automated. Additive manufacturing is increasingly disrupting distribution chains. | A lot of manufacturing is now automated. Offshoring continues except where automation can bring greater cost reductions. There is an element of disruption to existing distribution and supply chains due to local additive manufacturing (which is thriving in the grey economy). |
| Sharing economy | Owing to positive attitudes to ICT and a lack of government funds, worker communities have been set up for the mutual benefit of their members. | A collaborative sharing economy is the norm. Most people are self-employed and belong to an online worker/job association/ community that controls the supply of labour, finds contracts and puts multidisciplinary teams together. Personal ownership of assets, other than ICT, has declined. | The sharing economy is commonly used by corporations to reduce costs. Some individuals form online work 'collectives' in an attempt to improve work conditions. | The sharing economy exists mainly in the grey economy, an untaxable undercurrent of activity. |
| Pseudo self-employment | There has been only a slight increase over the last decade, as governments responded to this problem early. | Pseudo self-employment is rare. | Pseudo self-employment by large corporations is common. | Significant numbers of workers fall into this category. |
| Data and the knowledge economy | The economic value of data and knowledge is recognised as being as important as that of other goods and services. | The economic value of data and knowledge is recognised as being as important as that of other goods and services. | The economic value of data and knowledge is recognised as being as important as that of other goods and services. | The economic value of data and knowledge is increasingly being recognised as being as important as that of other goods and services. |

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| | Workers use cloud computing to work collaboratively and to share data and knowledge. | Datasets are traded through a regulated framework. Workers use cloud computing to work collaboratively and to share data and knowledge. | While big businesses carefully guard their IP, some communities have been created that use cloud computing to work collaboratively and to share data and knowledge. Some micro-enterprises and SMEs share data for mutual business benefit. | Companies seek to gain an advantage from IoT data sources. Workers are beginning to use cloud computing to work collaboratively and to share data and knowledge. |
| Workforce demographics | The EU population continues to fall, owing to low birth rates and the emigration of talented young people. The number of different generations in the workplace and the average age of the workforce have risen, and there is an increasing number of workers with chronic and complex health conditions because people are retiring later. The proportion of women in the workforce continues to grow. | The EU population has stabilised owing to carefully controlled immigration. The number of different generations in the workplace and the average age of the workforce have risen, and there is an increasing number of workers with chronic and complex health conditions because people are retiring later. The diverse workforce reflects the demographics of the population owing to improved accessibility of work to everyone alike. | The EU population has stabilised because businesses buy in the skills they need rather than developing them in-house. The number of different generations in the workplace and the average age of the workforce have risen, and there is an increasing number of workers with chronic and complex health conditions. The proportion of women in the workforce continues to grow. | The EU population continues to fall, owing to low birth rates and the emigration of talented young people. The number of different generations in the workplace and the average age of the workforce have risen, and there is an increasing number of workers with chronic and complex health conditions because people are retiring later. The proportion of women in the workforce continues to grow. |

**Table 5: Cross-scenario impact analysis for ICT-ETs**

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| Robotics, autonomy and AI | Low wages, high unemployment and the desire to protect existing jobs have limited investment in technology to areas that are most established, such as robotics and automation. Most new applications have been ones that support or protect workers. 'Lights-out' manufacturing has grown slowly.<br>AI has mostly been used as a tool as part of existing jobs, rather than to replace workers completely.<br>There has been moderate innovation and growth in the use of autonomous vehicles, including drones. | Robots and AI perform any routine and repetitive work. Collaborative robots are common in workplaces. AI is part of many aspects of daily life, including work. AI has replaced many medium-skilled professional jobs and with the emergence of artificial general intelligence (AGI) is increasingly replacing higher-skilled jobs in some areas. Bionic devices and exoskeletons support an ageing population in work. There is high innovation and growth in the use of autonomous vehicles, including drones. | Robots and AI perform most routine and repetitive work. AI has significantly impacted on medium-skilled professional jobs, which has led to a 'hollowing out' of the workforce. Robots are increasingly powerful and carry out ever more complex tasks, sometimes alongside humans.<br>There has been ongoing innovation and growth in the use of autonomous vehicles, particularly drones. | Significant developments in the automation of jobs, eliminating large parts of manufacturing. Narrow AI used to cut costs, but innovation slows as investment dries up.<br>There have been low innovation and growth in the use of autonomous vehicles and a moderate growth in the use of drones |
| Internet of Things and big data | Growth has been constrained by the lack of investment in the supporting infrastructure and concerns about privacy and cyber-security. The greatest progress has been in the social welfare, health and social care sectors. | The IoT is widespread in all aspects of modern life; the majority of devices are 'smart' and connected. | The IoT is part of most aspects of daily life, including work. Performance, productivity, health statistics and even leisure time are monitored by employers. | The IoT and big data are used extensively to monitor and track workforce performance. |

| Key trend/driver | Scenario 1<br>EVOLUTION | Scenario 2<br>TRANSFORMATION | Scenario 3<br>EXPLOITATION | Scenario 4<br>FRAGMENTATION |
|---|---|---|---|---|
| Cyber-security | Cyber-attacks continue to be a problem and the response has mainly been restricted to awareness campaigns to alert individuals and business to the threats and how to minimise the risks, rather than investment in infrastructure. | Towards the beginning of the decade, a number of very serious cyber-attacks caused havoc in some European countries. Now there is a well-funded, coordinated response to cyber threats, so attacks generally have little, if any, impact. Cyber-security skills continue to be in demand and job numbers in this area are significant and increasing. | Lack of investment and lack of cooperation between corporations and government have meant that cyber-attacks are increasingly common, affecting both infrastructure and business. Cyber-security skills have been increasingly in demand over the decade, resulting in a growth area for employment. | There have been many failures as a result of cyber-attacks due to lack of investment and planning. There are opportunities for the cyber-defence industry |
| Augmented and virtual reality (AR and VR) | AR and VR developments are restricted by limited investment. However, there has been some adoption in the healthcare sector, for training purposes | VR and AR are widely used for both leisure and work purposes, particularly for collaboration, education and training as part of workers' continuous professional development. | VR and AR are widely used for both leisure and work purposes. Employers use AR and VR primarily to increase productivity. | Developments in AR and VR are generally moderate. However, they are used to maximise worker productivity or as a way of reducing training costs wherever possible. |
| Communication networks | The main development over the last decade has been 5G mobile networks. This has focused on the main urban areas and coverage in remote areas has been constrained by lack of investment. | 5G mobile networks are widespread throughout Europe, including in rural areas and on transport. | The majority of the EU is now connected to 5G mobile networks; however, more rural parts of Europe have either no mobile signal or last-generation 3G or 4G services. | Development of 5G networks is focused on profitable areas only, generally industrial areas and cities; there is no government investment in networks. |

| Key trend/driver | Scenario 1 EVOLUTION | Scenario 2 TRANSFORMATION | Scenario 3 EXPLOITATION | Scenario 4 FRAGMENTATION |
|---|---|---|---|---|
| Human interfaces | Voice control is used to improve productivity in many sectors. More advanced technologies have been constrained by limits on investment and privacy concerns. | Voice and gesture controls are a normal feature of most everyday ICT devices used at home and at work. Bionics are commonly used. There is some early adoption of direct brain-to-computer interfaces. | Voice and gesture controls are a common feature of ICT devices used at work and at home. Bionics are also used to improve productivity. There is some early adoption of direct brain-to-computer interfaces. | There have been limited developments in voice and gesture controls and some early adoption of bionics. |
| Built-in OSH | There has been a strong drive to implement this but progress has been slow because of limits on investment. | Online employment associations ('guilds'), along with AI, encourage and support improvements in working practices, safety and well-being. | Corporations have no real desire to implement this, unless it could also improve performance. | Minimal — implemented only where a lack of OSH protection also significantly affects worker productivity. |

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