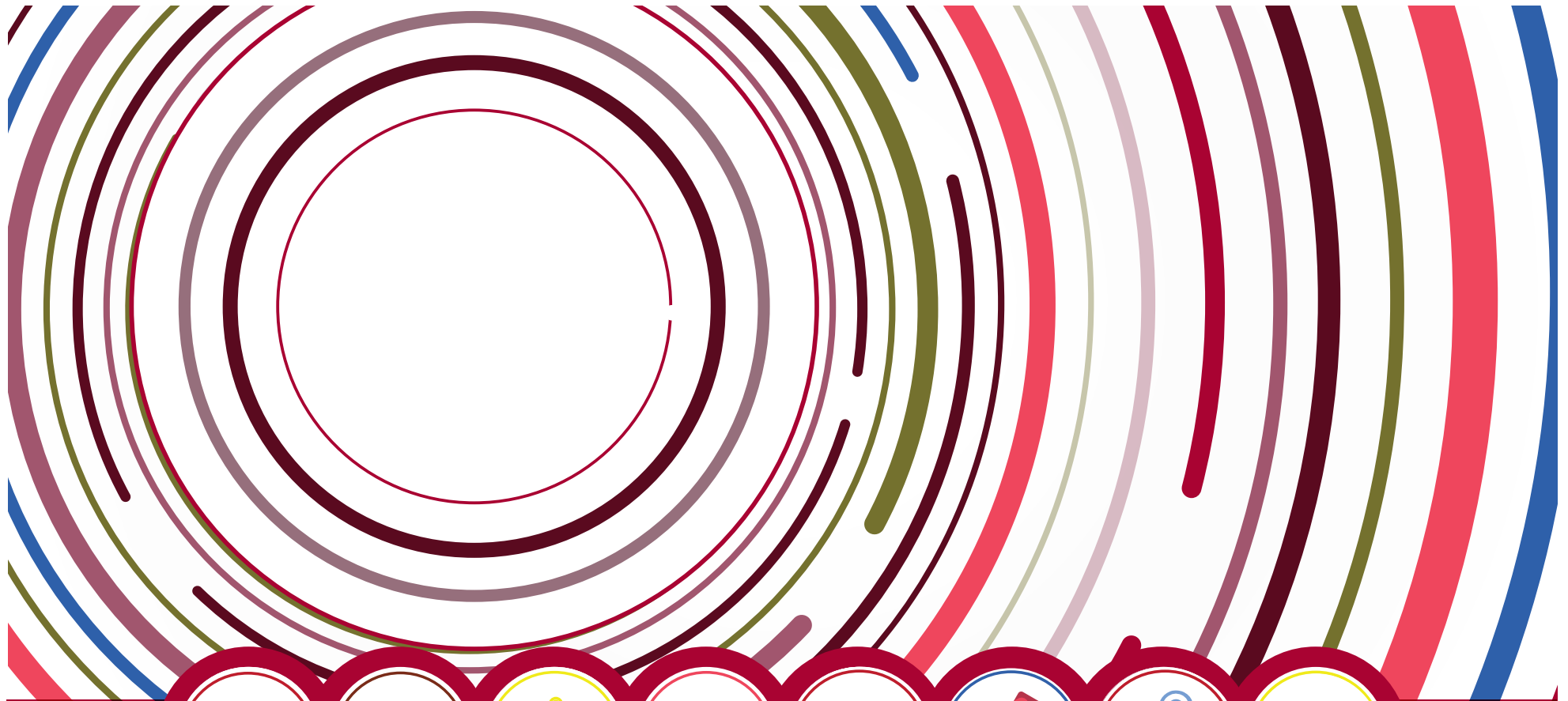


FORESIGHT REPORT

The human impact of the changing nature of work



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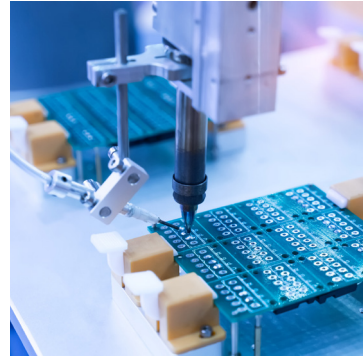
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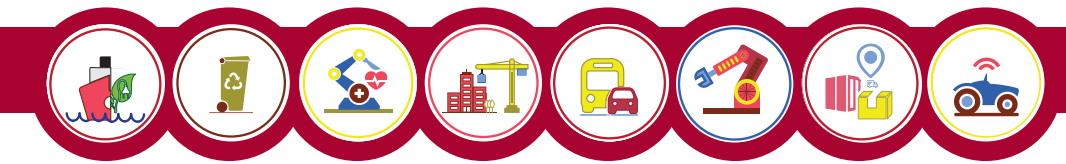


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Foreword



It is important that HSE, like other organisations, plans for tomorrow – and does this today. We need to think about today's problems, scan the horizon, and anticipate potential future issues that may be coming towards us.

It is critical that we are constantly sighted on the changing nature of work and potential impacts on health and safety. Hence, it is increasingly important that HSE uses foresight thinking in the development of its strategies.

In terms of looking ahead, our foresight report provides an opportunity to raise awareness of potential futures, enabling people to be vigilant and better prepared for the future. It paves the way for people to have the right conversations about their futures and what they need to do to prevent risk from accumulating in complex systems. This report will be a useful tool for HSE's Board, senior managers and teams to begin structured conversations about future challenges.

I hope you enjoy reading this report and find it useful, including to help structure conversations that will help you respond to the challenges and opportunities created by the changing world of work.

Professor Andrew Curran
Chief Scientific Adviser and Director of Research



Introduction

Many of the risks currently faced by workers will still exist in the future. However, the world in which work takes place and the nature of work will be different.

Our fourth annual report focuses on the changing nature of work and the potential impact on workers within the next four to ten years. The report consists of a series of short stories, based on a number of sectors of importance to HSE.

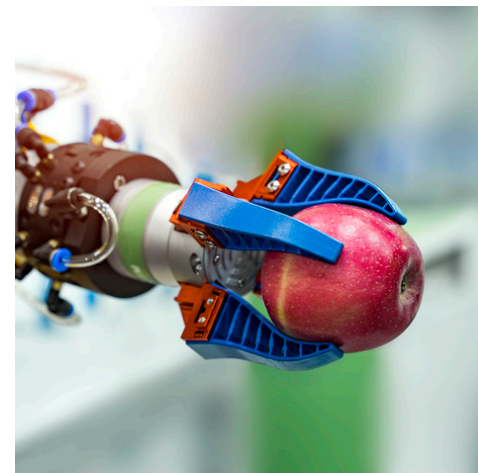
Each story is purely fictional based on our understanding of the potential human impact of the changing nature of work. It describes a future world viewed through a particular 'lens', which brings together three changes in the nature of work. These have been selected based on our horizon scanning and conversations with key HSE stakeholders.

The changes in the nature of work are shown in the interlinking circles at the top of each story. The stories describe how the changes might interact and impact positively and/or negatively on the health, safety and wellbeing of a hypothetical worker. The last story also incorporates the potential for human impact on a societal scale.

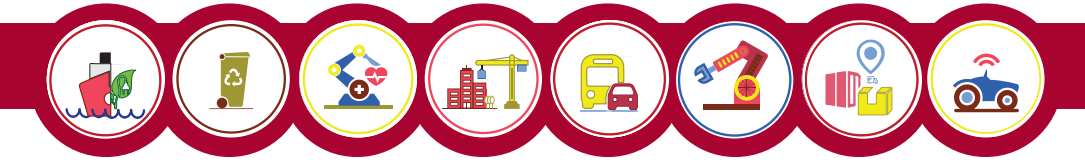
In writing these stories we considered five broad themes that reflect the changing nature of work (overview on page 5):

- Changes in workforce characteristics.
- New work equipment and tools.
- Changes to the working environment.
- New ways of organising and managing work.
- Different skills, knowledge and information.

To help with your thinking, we have provided some conversation starters to help you consider what this might mean in your specific context.



How to use this report



We have structured this report to provide thought-provoking conversation starters to help you envisage what the working future might look like in your area(s) of work or interest.

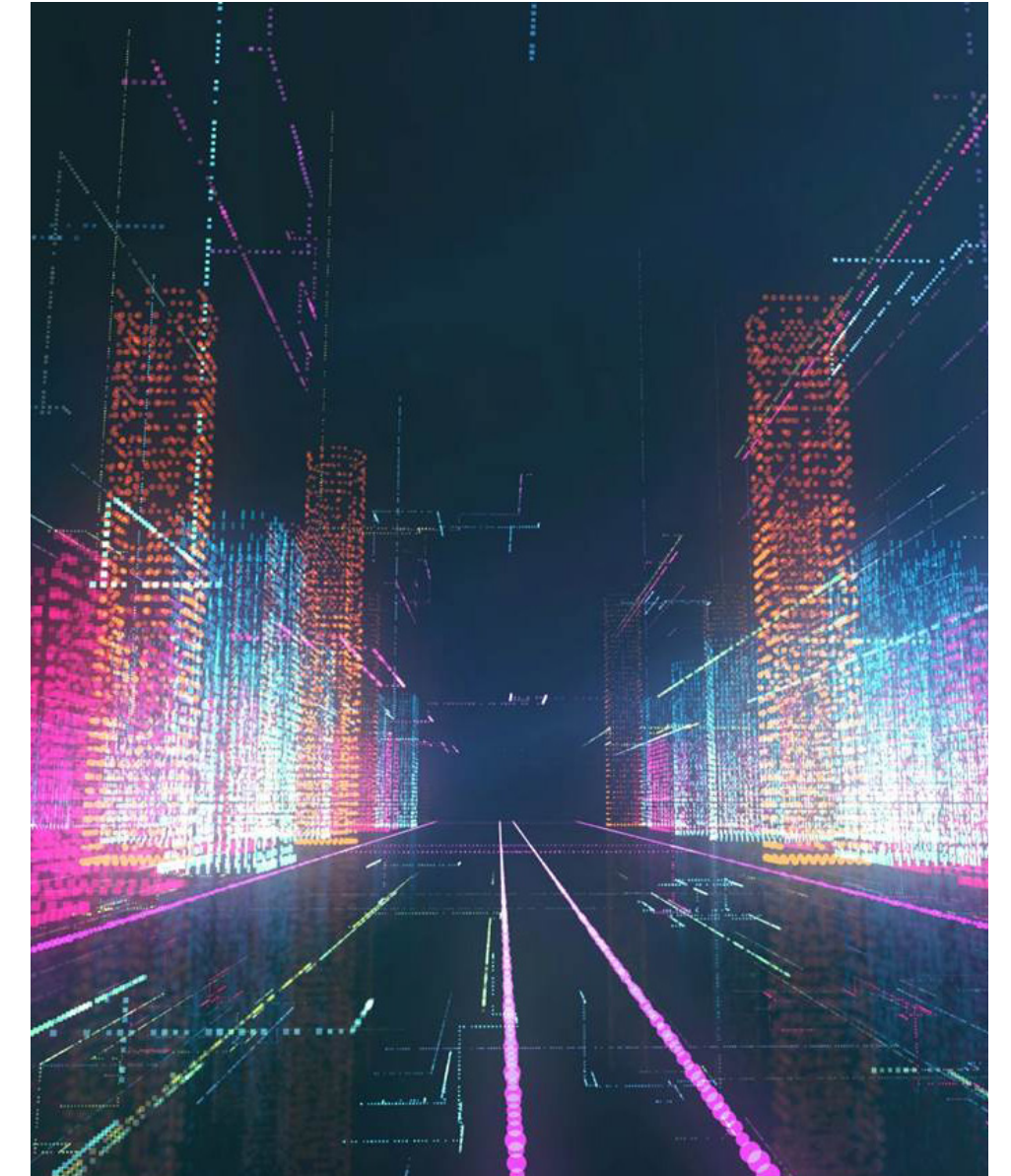
The stories offered are not intended to be a comprehensive or rigorous assessment of the issues, but sufficient to enable you to consider what it might mean for you, by asking the 'So what for me?' question:

"What might these potential changes mean for health, safety and wellbeing in my area of work / interest?"

We invite you, the reader, to use these stories to help develop your thinking so you can influence the future world of work in a positive way.

If you look at the stories from other perspectives, or from the viewpoint of other workers, they may present different opportunities and challenges to those outlined in this report.

You can share ideas and/or let us know what you think about this report by emailing HSE's Foresight Centre at foresightcentre@hse.gov.uk



About HSE's Foresight Centre

The world of work is changing and we must continue to adapt. HSE's Foresight Centre applies futures techniques, including horizon scanning and scenario building, to help HSE and external stakeholders to reflect on the possible, revisit assumptions and explore implications to inform how we adapt.

It is important to note that futures techniques do not predict the future, rather they provide decision-makers with the opportunity to anticipate the changing future occupational landscape. This aligns with the government's aim to help businesses grow and to do so in a healthy, safe and productive way.

The Government Office for Science defines horizon scanning as:




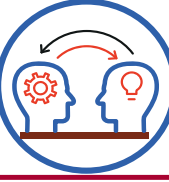

"A systematic examination of information to identify potential threats, risks, emerging issues and opportunities, beyond the Parliamentary term, allowing for better preparedness and the incorporation of mitigation and exploitation into the policy-making process."

The Foresight Centre targets its activity where it can have greatest impact to contribute towards the delivery of HSE's mission, and as a result, help deliver positive outcomes that align with Great Britain's National Priorities of most relevance to HSE.



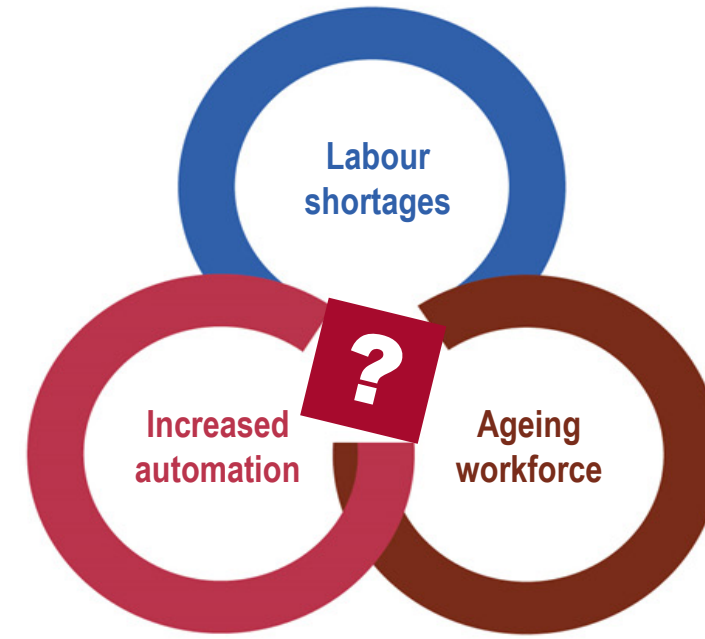
Summary of relevant GB National Priorities	
Health	Physical and mental, meeting the needs of an ageing society
Productivity	UK at the cutting edge on commercialisation of new technology
Good Work	A stronger, fairer economy, protecting workers' rights
Global GB	Global leadership, exports and a strong new relationship with Europe
Energy & Environment	Developing safe and sustainable energy sources, mitigating major hazard risks and reflecting societal focus on environment protection
Mobility	Innovation in the movement of people, goods and services
Innovation	Transform productivity in key sectors and for SMEs

Some ways in which the nature of work is changing

 New work equipment and tools	Increased automation - Autonomous Vehicles - Building Information Management (BIM) - Precision Manufacturing - Robotics - Scaling up - Wearable devices
 Changes in workforce characteristics	Ageing workforce - Labour shortages
 Changes to working environment	Consumer behaviour - Net-zero carbon economy - Offsite construction - Work intensification
 Different skills, knowledge and information	Skills keeping pace with change - Big data - Knowledge transfer
 New ways of organising and managing work	Gig economy - Management by algorithm - New delivery models

Agriculture

Jack, a farmer in his late fifties, is one of a growing number of older workers learning to apply new skills in a changing industry. Climate change, diminishing resources and environmental concerns are putting pressure on him to improve efficiency, increase production, reduce costs and reduce environmental impact.



In four to ten years time: The use of sensors, GPS-guided vehicles, drones and robotics is increasing and this and other technology is providing an unprecedented opportunity to improve quality and yields and to mitigate some of the losses associated with the various challenges faced by the sector. The use of small, light and smart machines is increasing which could result in less soil compaction. Smarter application of fertiliser and pesticides is reducing environmental impact.

The decreasing and ageing rural population is also having major implications for the sector. Labour shortages are increasing the uptake of technology on some of the larger farms and driving innovation. Technology is enabling farmers to work even later in life and although there are more farmers working with

chronic health conditions, the technology helps to make the work less physically demanding. There is also hope that the increased use of technology and new skills in agriculture could encourage a new generation of younger workers into farming.

The cost of farming equipment has increased significantly over the years and as a result leasing of farming equipment and use of contractors in the sector has increased. Leasing is enabling some of the smaller farms to make use of the latest technological innovations, reduce costs and become more competitive.

Jack has followed the rapid developments in robotics and autonomous vehicle technology and believes this will help to make farming less labour intensive and

dangerous by taking over some of the dirty, and monotonous jobs and reducing exposure to hazardous substances, as well as helping to reduce its environmental burden. Farming could become more supervisory and less “hands on” as a result. Although some fear this could result in task deprivation and deskilling, with the farmer becoming a decision-maker rather than a doer, Jack recognises that developing new technical and agri-economic skills could mean the farm becoming more profitable. Introduction of new technologies may introduce new challenges.

Operators may be required to oversee an increasing number of processes remotely, increasing cognitive demand. A mix of new and old technologies on the farm could also create new risks if operators make assumptions about how the technology may behave.



However, removing the operator from hazardous tasks can improve health and safety and reduce the need for interventions .

While some of his neighbours have scaled up to become industrialised ‘mega farms’, in order to remain viable, others have concentrated on specialist and high-quality produce. Jack has scaled up production to supply feed and biomass to a local industrialised ‘mega farm’. His cousin produces high quality lamb for high-end restaurants in the area, which is then served with fresh salads grown in a nearby vertical farm.

Employing a GPS-guided tractor to plough the fields enables farmers to keep track of their position, allowing precision planting of seeds and application of fertiliser, saving money and reducing environmental

damage. With the computer in control they barely have to steer, making the job easier and enabling them to work for longer periods. They are looking forward to the day when ploughing, sowing and harvesting by self-driving autonomous vehicles means they will not have to step into the field at all.

Developments in sensor and image-recognition technology enable remote monitoring of crops. By analysing data collected from small sensors embedded in the field, a smartphone app indicates when the crops require water or nutrients and advises when the crop is ready to harvest. They also use a drone fitted with hyperspectral cameras to survey their crops and identify any problems, saving time and money. The use of data in these ways enables more efficient use of resources.

Conversation Starters...

- ✓ What are the health implications of working 24/7?
- ✓ What if the technology fails and decision-making behaviour has become over-reliant on the technology?

Waste and Recycling

Les is a waste and recycling driver who works as part of a collection crew who carry out household collections. By industry standards, at 41 year's old she is young for this role, but was able to develop her career over ten years through the company's in-house Academy Scheme, implemented to attract and retain younger staff. Large goods vehicle (LGV) driver shortages in a competitive skills market have led to recognition/accreditation schemes and industry body qualifications being made available. The collection crew's job has changed over time as society has responded to the unfolding climate change crisis. As society moves towards a circular economy and zero waste government policies, waste has become widely viewed as a resource and the industry has shifted from traditional waste management to resource management.

In four to ten years time: There has been a big push from government and local authorities in England and other Home Nations to move to a single standardised collection model, including a core set of dry, recyclable household materials and a more joined-up approach to dealing with food waste. Increased recycling volumes have led to the use of more box-type containers, which has increased Les's manual handling tasks at the kerbside. However, intrinsically safer design improvements have mitigated some of the musculoskeletal (MSD) risks and can also reduce noise levels, particularly from glass collections.

Increased environmental awareness among the general public means many householders want to comply with kerbside waste sorting to help protect the environment.

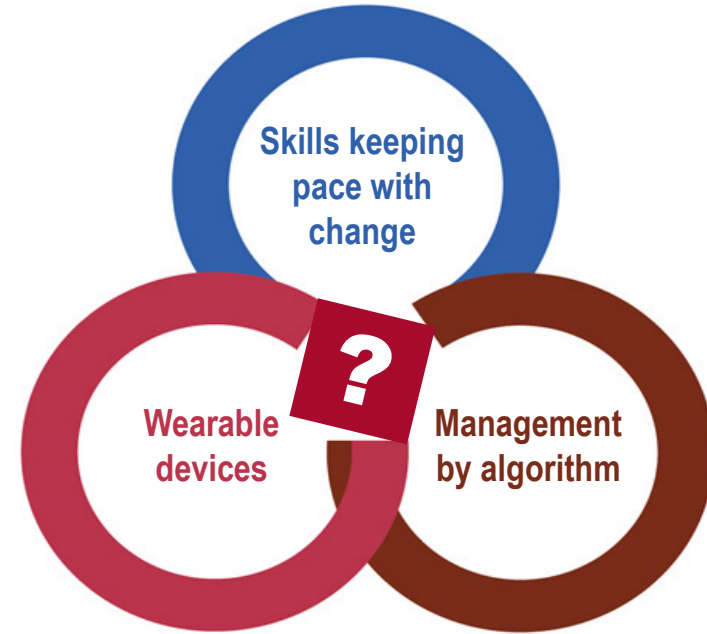
However, when more complicated collection rules have been introduced, which have included non-compliance penalties and fines, the risk of Les encountering violence and aggression from householders has increased.

Increasingly complex collections have created a need for greater optimisation of this team's collection routes. GPS mapping algorithms are already in use for efficiency and safety. This technology has been upgraded, incorporating machine learning and Artificial Intelligence (AI) to help deliver more balanced vehicle payloads and lower fuel consumption alongside improved crew resource management. Les uses a mobile App installed on her smart phone and/or dashboard tablet to communicate with the software and obtain optimised collection routes, timings and

crewing requirements.

The software matches resource to projected needs and takes into account real-time information such as traffic updates and collection volumes (from on-board sensors). It aims to maximise efficiency whilst mitigating musculoskeletal risks and fatigue, for example, by recommending planned rest breaks. However, Les's crew sometimes skip their planned break in order to keep up with or get ahead of schedule. The software provides value for money as it aims to reduce costs over time, whilst maximising yield and supporting health and safety.

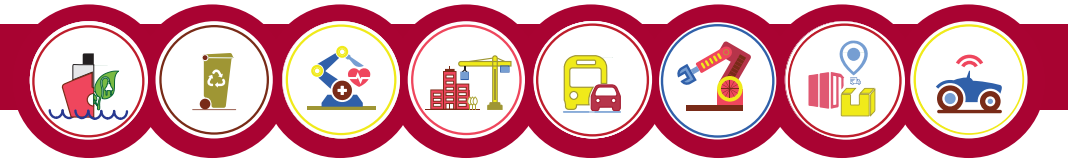
This waste management company has recently introduced smart-tracking technology, in the form of 360-degree video surveillance cameras on trucks,



body-worn cameras and connected sensor devices incorporated in the workers' required safety workwear.

The wearable devices and cameras passively monitor individual and team locations, movement and proximity monitoring. Wearing these devices encourages crew members to work in safe ways and helps to protect the health and safety of the crew and members of the public. Les's supervisor shares health and safety improvement outputs with the collection crews at regular pre-shift safety briefings.

Wearable devices and increased surveillance were introduced by the company as part of their effort to do more occupational health monitoring and help Les and her co-workers feel more valued and more engaged with health and safety.



Video clips have improved inductions for new staff, which have become increasingly interactive and body cameras enable evidence collection for kerbside sorting non-compliance by householders. However, on the downside, there is the risk that Les and her co-workers could feel their productivity is being tracked, which could be a cause of workplace stress.

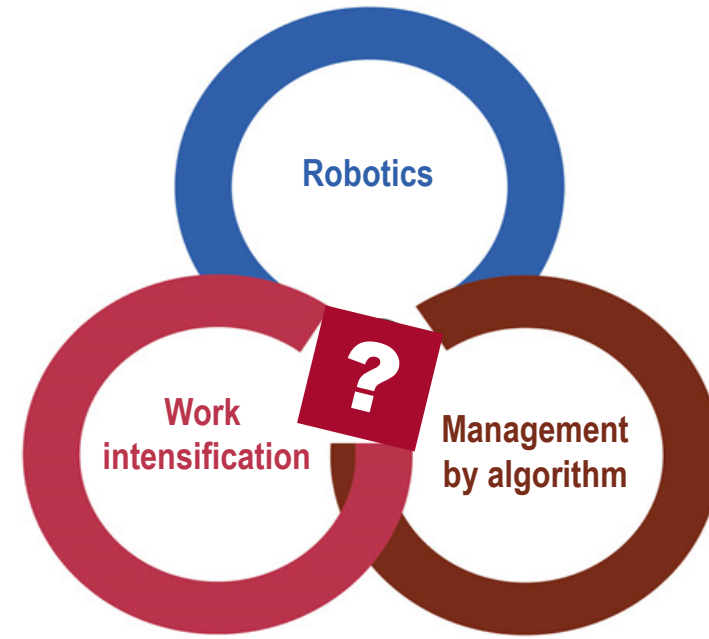
The future implementation of smart personal protective equipment, smart surveillance and increasing use of electric and autonomous vehicles, alongside the continued evolution of vehicle and container designs, mean that Les will need to maintain an adaptable skill set to keep pace with change and adapt to the health and safety requirements of their changing workplace.

? Conversation Starters...

- ✓ What work-around behaviours might be adopted if technology is used to manage work?
- ✓ What if technology is increasingly used for workplace surveillance?
- ✓ What if skills are not kept up to date?

Healthcare

Alex is an internationally recognised surgeon, and teaching consultant in a very specialist field, who extensively uses robotic surgical equipment. As a result, she has an increasingly high proportion of complex and high-risk surgical procedures in her caseload. She is experiencing frequent back, shoulder and neck pain. Alex has, therefore temporarily reduced her caseload in the hope that this will enable her to recover without having to take sick leave.



In four to ten years time: The use of robotic surgical equipment is now more widely available for many routine procedures as well as more complex ones. To date the primary focus of the surgical teams and designers of such equipment has been improving outcomes for patients. Innovations have, for example, reduced the number and severity of complications and improved recovery outcomes.

As more features have been added to the robotic equipment the number of controls, information display screens and space the equipment takes up in the theatre has also increased. This means that the surgical teams often have to maintain difficult and tiring postures, along with high levels of concentration, for extended periods of time.

Surgical procedures, when using robotic equipment, are more efficient so there are fewer opportunities for natural breaks. In addition, surgeons are spending more time doing surgery as the more routine aspects of a surgeon's job, such as follow-up and monitoring, are now being done in GP surgeries or through remote monitoring and medication using smart wearable devices and Artificial Intelligence (AI).

These combined changes have increased the risk of fatigue, back, shoulder and neck pain and work-related stress for Alex and other surgeons.



Alex's reduced caseload has allowed more time to be spent providing advice to designers of robotic surgical equipment. During a design meeting, to discuss possible future innovations, Alex explained that the new features would increase what was already a too high risk of work-related ill-health for the surgical teams.

Alex was able to use real-life examples to make the case that future innovations needed to not only ensure good outcomes for patients but also minimise the physical and mental strain on the surgical team using the equipment. After all, patient outcomes were not best served if experienced surgeons or members of their team had to take time off due to work-related ill health for example because this could increase patient waiting times.

The design team agreed to use data collected during surgical procedures to inform the incorporation of latest developments in other fields. These would include developments in manual handling robotics. Also the use of smart wearable devices, to monitor physical and psychological stress, which are used by scheduling algorithms to incorporate breaks and rotate tasks as part of a package of organisational measures for managing physical and mental stress.

It is hoped that the next prototypes will enable future surgeons to deliver continuous improvements for patients undergoing these vital surgical procedures without experiencing work-related ill health issues such as those that Alex has.

? Conversation Starters...

- ✓ What might the implications be if precision tasks are done for extended periods of time?
- ✓ How might the prevalence of work-related stress change if skilled workers with high job demands have a longer working life?
- ✓ Has the design of technological solutions fully considered the impact on the user and their behaviours?

Construction

Charlie is one of a growing number of younger people applying his technology skills in a sector that has undergone radical change. Modern methods of construction, using new materials, digital working and precision manufacturing techniques, have facilitated a transition to off-site manufacturing and different ways of managing construction sites, to build quicker and cheaper, whilst maintaining build quality.

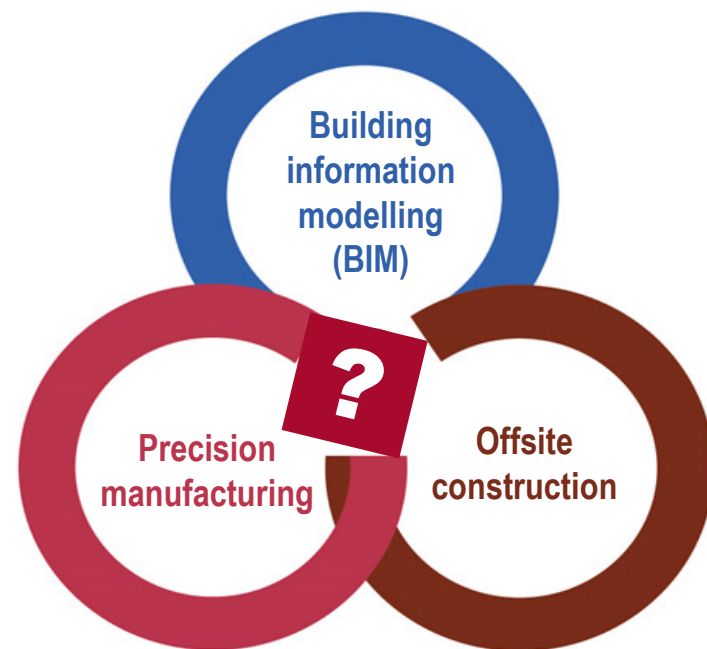
In four to ten years time: There has been an increase in the use of technology-based tools and equipment, such as: remotely operated drones and autonomous vehicles, robotics and 3-D printing, which are linked to and help to inform building information modelling systems (BIM) via 5G networks. These systems can identify and manage health and safety risks on-site and ensure that planning and design are realised through the build.

Virtual reality (VR) allows construction teams to view each aspect of the construction process in sequence on the ground, before they happen.

VR is also applied to site induction for new workers. The use of augmented reality and wearable devices enables information to be conveyed to workers on-site, alerting them to risks and to provide monitoring of their exposure.

Combining this with biometric identity, time and attendance solutions, capturing data at site entry/exit, helps contractors to record, manage and report on individuals working on their sites and to inform health tracking through digital health passports.

In response to pressures for the industry to help address climate change, greener, more eco-friendly construction is promoted with re-use and recycling of materials and use of carbon-neutral materials becoming increasingly important.



Changed ways of working may lead to the need for bulk storage of raw materials on-site. Depending on the nature of these materials, this may have the potential to give rise to catastrophic major incidents with off-site consequences.

The average age profile of the sector continues to rise despite efforts to render the industry more attractive to both younger workers and women. Two factors that have driven the uptake of technology are loss in the availability of migrant workers and shortage of key skills.

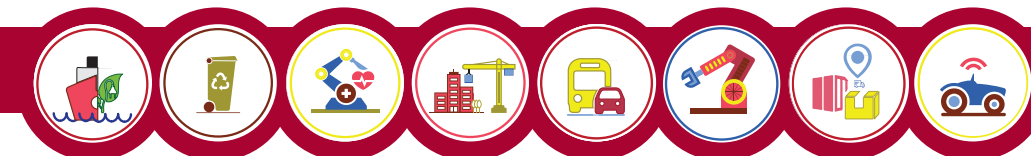


There has been a shift in the risk profile of the sector, with fewer accidents on site but more occurring within the supply chain. Technological change has removed some of the physical construction risks, but on site, a greater proportion of falls are being reported (in part, due to the increased prevalence of older workers) and there are concerns about the poor risk perception of less experienced workers.

Charlie primarily uses BIM to generate and manage digital representations of new buildings, has played computer games since childhood, and is proficient in using the game controls that now operate many construction tools.

However, Charlie lacks the design experience of older workers, and this may have a negative impact on decision-making which is based on the digital solutions Charlie develops and delivers.

The lack of sufficiently skilled people to use the new technological tools and equipment means that Charlie is under constant pressure to deliver outputs. He may feel unable to cope with the demands of the job resulting in incidences of work-related stress. However, industry initiatives around this area, starting right from the apprenticeship level, have helped to build a responsive and supportive culture.



Conversation Starters...

- ✓ What if there are growing numbers of younger vulnerable workers who lack experience of their work environment and tasks?
- ✓ What if technology increases job demands and workplace cultures are not adapted to support the increased demands on workers?

Transport

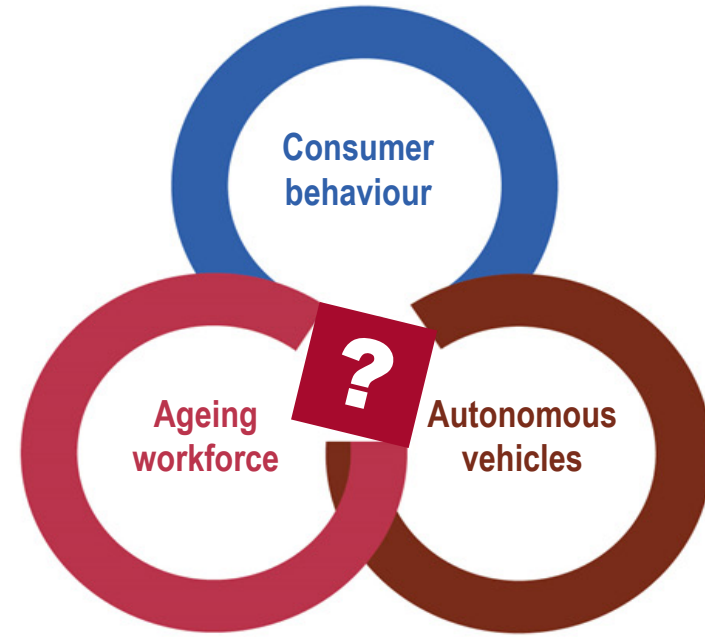
Max a transport sector worker in her early sixties is one of a growing number of older workers driving a range of vehicles – from small ‘last mile’ delivery vehicles to large 44 tonne Heavy Goods Vehicles (HGVs). Her work is peripatetic – travelling from place to place working for multiple different employers. She works long hours – often unaware of how many hours she has worked. Max suffers from fatigue and finds it a struggle to have sufficient recovery time away from work. She also suffers from a range of medical conditions. Frequent and continual jumping down from the cab has left her with pain in the knees, hips and lower back. Max's eyesight is deteriorating, and many years of driving and unhealthy eating has resulted in type 2 diabetes, controlled with the help of tablets.

In four to ten years time: The pressure to switch to cleaner fuels and move away from diesel has driven a step change in the number of autonomous and electric vehicles on the roads. Whilst there is greater road usage and more congestion, the amount of revenue for maintenance and improvements to the road infrastructure has declined.

There is increased pressure to deliver goods more quickly (sometimes within a few minutes) driven by the exponential increase in on-line sales. To facilitate the faster movement of goods, companies have expanded their networks of regional distribution centres.

Remote tracking of commercial vehicles has become commonplace and advances in telematics, (using telecommunications to connect to vehicle information), plays a key role in how Max's health and safety is managed.

An increasing number of safety protections are being added to their vehicles and the road environment. Assisted-driving features are standard within vehicles and include cruise control, automatic emergency braking and lane departure warnings. Speed limit and traffic congestion information is beamed directly to the driver's dashboard – enabled by 5G technology.

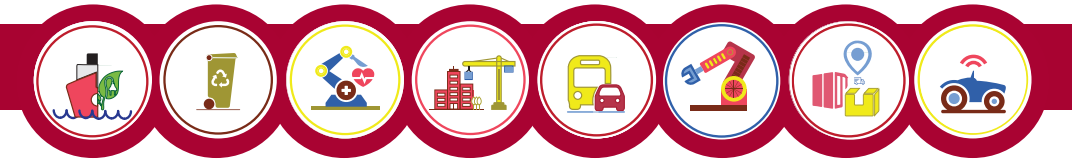


Whilst the assisted-driving features reduce hazards associated with driver error and improve safety, they have removed control from Max who feels increasingly isolated from her vehicle, losing any ‘feel’ for what is happening with the trailer.

Max is prone to lapses of concentration whilst driving and recently collided with one of the growing number of cyclists on the roads. From the telematics data, she is aware that she is prone to micro-sleeps whilst driving.



Max's work can be unpredictable, intense and time-pressured – typical of those working in the expanding gig economy. Whilst Max would like to reduce her hours, she has a financial need to continue working for at least the next five years – with demand for her skills unlikely to diminish in the foreseeable future.

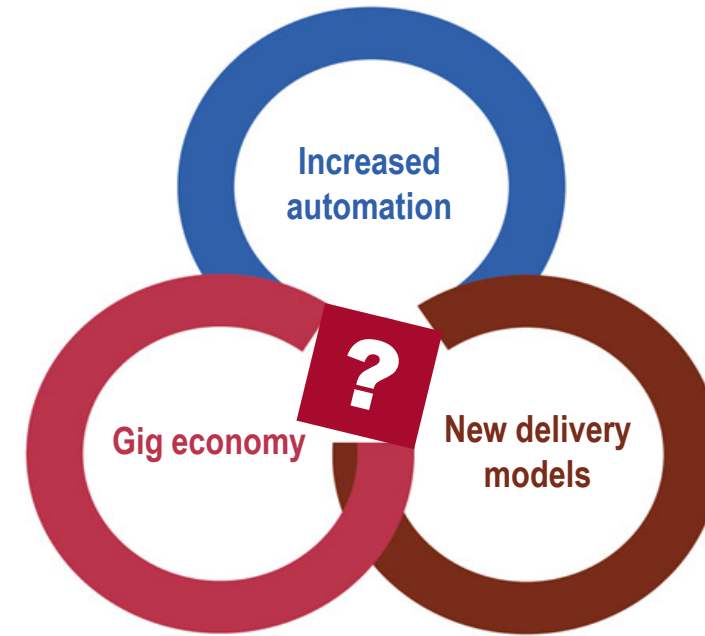


Conversation Starters...

- ✓ What if workers do not have sufficient recovery time between periods of work?
- ✓ How might a worker change their behaviour in order to cope with changes in the nature of their work, and to compensate for health issues?

Transport - Gig Economy

Ashley, a skilled migrant worker in his mid-thirties, undertakes parcel delivery and courier services as one aspect of his working week. Ashley is responsible for providing a roadworthy vehicle, insurance and fuel and is paid per parcel delivered. Working within the 'on-demand' gig economy, Ashley's smartphone is essential - enabling him to secure jobs through clients' online platforms. His smartphone also allows the client to monitor their progress and parcel status.



In four to ten years time: Commercial and environmental pressures have led to fundamental changes to the make-up and operation of the UK delivery fleet. The combination of 5G and the Internet of Things (IoT) has revolutionised logistic management systems. Distributors track vehicles and the freight transported through the delivery network and harness the benefits of telematics - drawing on in-vehicle sensing and monitoring technology - to understand a vehicle's status (performance, diagnostics, fuel consumption, etc.) and the driver's performance and safety (behaviour, adherence to speed limits, fatigue monitoring, collision avoidance, etc.).

Further refinement of this technology has led to more widespread use of autonomous vehicles; on the

motorways, truck platooning, with a single driver in charge of a wirelessly connected convoy, is more prevalent.

The continued level of online retail sales remains a significant factor influencing the demand for delivery services, with flexibility and speed vital for the consumer. Whilst in the past, customers were willing to pay a premium and wait a few weeks for their deliveries, today customers want their parcels delivered next day and for free.

A variety of delivery models are in operation to address this, increasingly drawing on a network of mainly self-employed couriers, working in a variety of roles for multiple clients, on-call – 24 hours a day, seven days a week, 365 days a year – to cope with the

increasing professional driver shortages (due to an ageing workforce and lack of new entrants) experienced across the sector.

Climate concerns have resulted in government initiatives to reduce vehicle emissions in urban areas, through the introduction of low-emission zones, as well as the introduction of target dates to phase out the sale of new fossil-fuel vehicles.

An exponential increase in the use of smaller goods vehicles has resulted. However, these strategies have been instrumental in increasing electric vehicle development, application and use. Electric vehicle solutions for last-mile delivery – such as e-bikes, pods, shuttles and drones – have become well established.



Battery technology continues to develop to improve vehicle range and reduce charging intervals and innovative ways to provide rapid vehicle charging are increasingly being made available.

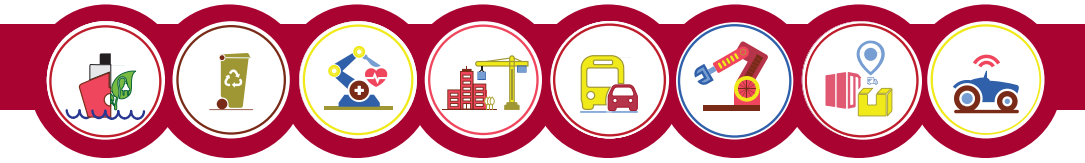
Infrastructure has also had to adapt. Town planning has recognised the need to cope with greater congestion. More sustainable and durable roads are being produced through the utilisation of recyclable materials and increased, localised warehouse provision has been made to ensure that goods are close to consumers to facilitate their supply.

Being self-employed allows Ashley to have some choice about the jobs he undertakes but as a result, he has responsibility for his own health and safety. Being freelance means that there is no guarantee of jobs

being available when needed.

However, the market is very buoyant and pressure to accept as many available jobs as possible puts Ashley at risk of fatigue, potentially driving excessive hours without breaks, particularly at certain times of the year. Seasonal demand brings particular work pressures.

In a competitive market, there is always the commercial pressure to undertake jobs for the lowest price, which impacts on the number of jobs that must be completed to earn enough money. Constant monitoring is an added source of stress. Driving is just one aspect of work Ashley undertakes, and is fitted around other work, all of which takes a physical and mental toll.



? Conversation Starters...

- ✓ What health and safety consequences might result from growing numbers of self-employed / freelance gig workers?
- ✓ What if people are increasingly moving between different sectors and working for multiple employers?

Manufacturing

Chris, who is in her early thirties, works for a highly digitalised electronic device manufacturer where many tasks and processes (both physical and intellectual) have been automated. Electronic devices and software, capture and analyse data from processes, work and workers and make decisions accordingly. Manufacturing processes are increasingly networked.

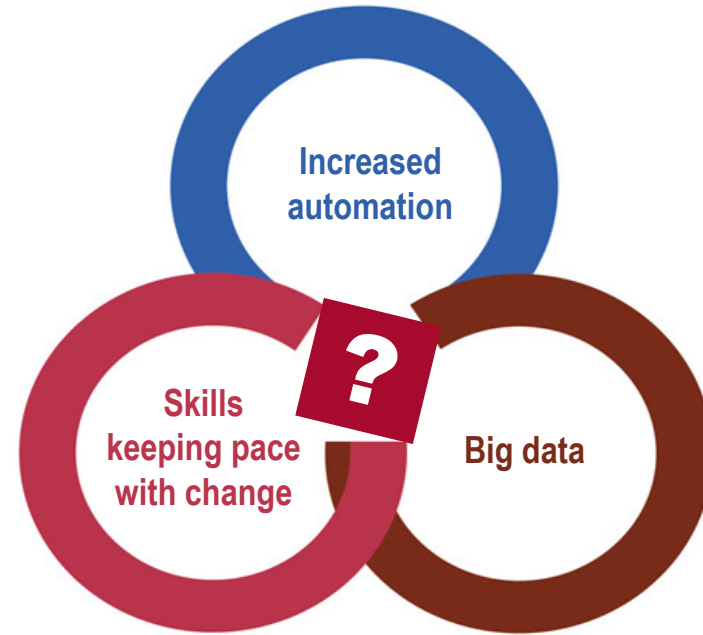
Chris is confident and skilled, interacting with a range of digital systems in the factory overseeing, managing and trouble-shooting automated systems e.g. collaborative robots or 3-D printers, or dealing with software issues.

In four to ten years time: There has been an increasing shortage of Science Technology Engineering and Mathematics (STEM) graduates, so Chris readily found work in this manufacturing company. Starting with a general engineering degree, she has had to regularly upskill to match the increasing requirements for this role, such as; advanced reasoning, problem-solving, interpersonal and project management skills.

The high-value manufacturing sector has changed dramatically as a result of ongoing rapid technological development. There has been an increase in the use of collaborative robots, and 3-D printing - along with an increase in the use of machine-learning algorithms to control and refine factory process.

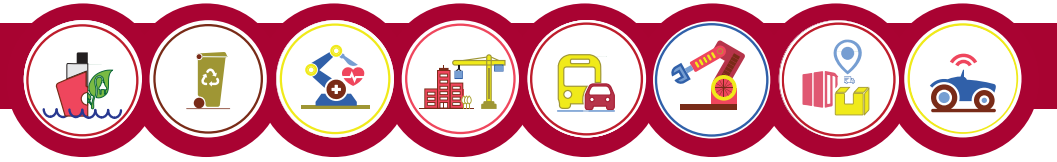
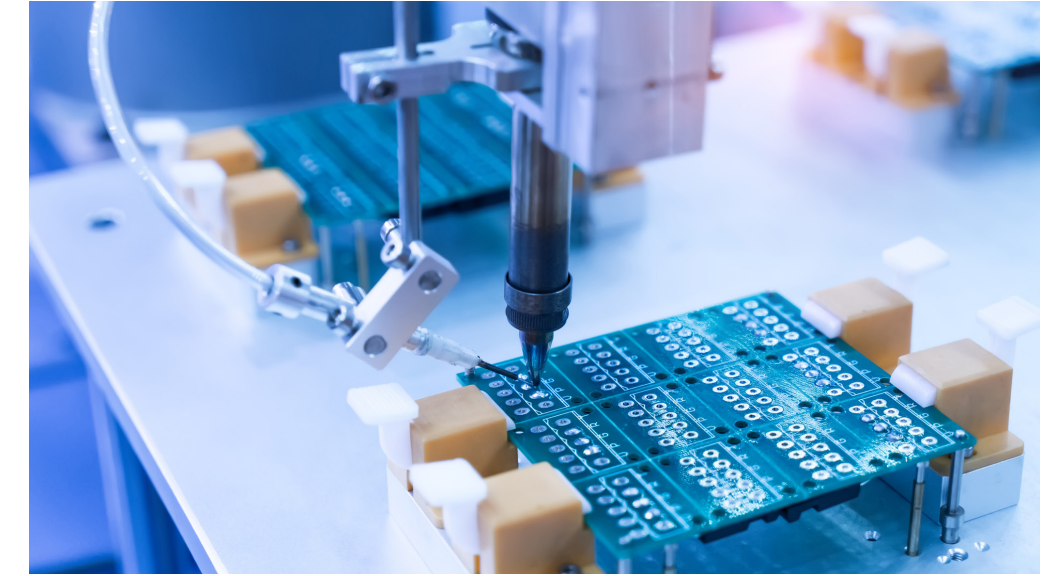
There are few jobs inside the factory, since routine and repeatable tasks have all been automated, which has consequently led to a significant reduction in health and safety incidents associated with manufacturing processes.

A high demand for personalised products (led by clothing and shoe manufacturers) has resulted in a personalisation economy, and most consumer electronics are now customised. To meet the demand, this factory has implemented digital tools such as agile software development and additive manufacturing; this means that factory equipment and systems are often updated or upgraded, consequently the worker needs to adapt to this frequent change and regularly update their learning.



These regular changes to the factory environment, correspondingly alter the risk profile of some work activities and this can challenge existing health and safety management processes.

Chris is often under pressure to deliver faster outputs and finds the intense, and sometimes unpredictable nature of this work, difficult at times. She frequently feels tired and sometimes makes errors (this has resulted in a few safety near-miss incidents in the past). Chris increasingly feels unable to cope with the demands of the job and is at risk of having work-related stress.



Conversation Starters...

- ✓ What if health and safety management processes cannot keep up with technological advances?
- ✓ What if workers suffer from work-related stress early in their careers?

Major Hazards

Tony is responsible for maintenance on a medium-sized chemical manufacturing plant that handles solvents. The plant, originally built in the 1950s, has been added to and modified considerably since then. Finances are tight, and the maintenance budget hasn't increased for several years. Spares are becoming hard to obtain, as a lot of the equipment isn't manufactured anymore. To replace some items with new equipment of differing configuration would mean wholesale changes to the plant, that aren't feasible under the current financial constraints. This means Tony needs to repair worn parts or replace them, like-for-like. Replacement parts are only available from the original manufacturer at a high price tag with import costs and long delivery delays. This equipment obsolescence has led to production stoppages and down-time.

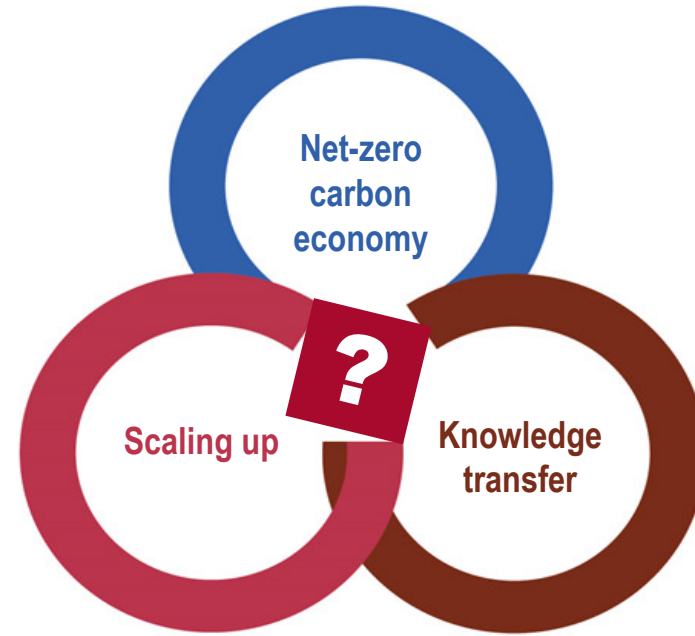
In four to ten years time: A new Additive Manufacturing (AM) service, offered by a local contractor means that Tony can get replacement parts on demand and more cheaply. The service makes new copies of old parts by creating a digital model of the old part which is then used to produce a new replica part.

The AM technique also means that the digital model can be altered to use alternative materials or less material, thereby saving money and weight. This means Tony doesn't have to alter the plant design as he can keep using the original equipment and just replace any degraded parts

The obvious advantages of AM are attractive, but there are some potential disadvantages that can erode engineering and quality safeguards or mean that

factors of safety may be lost with potentially serious implications. Parts made using AM do not have exactly the same mechanical properties as the parts they replace; they could behave differently in service and may suffer accelerated or different types of degradation.

The nature of the AM process, and variations in the raw material, may mean - even when producing repeated copies of the same part - small production variations can have a drastic impact on the final properties of the part in service. This could invalidate the original certification of the equipment as compliant with Pressure Equipment (Safety) and Dangerous Substances and Explosive Atmospheres Regulations.



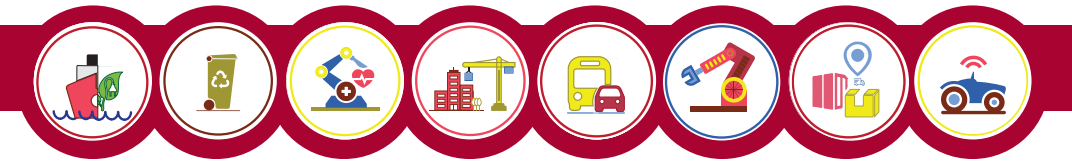
Tony's maintenance and operations colleagues did not fully appreciate the potential implications of such changes. Whilst intended to be 'like for like', such replacement components might still perform differently in service. How they degrade, erode, corrode or crack might vary. If so, this runs the potential risk of catastrophic failure, so any safety-critical replacements would require full quality assurance to ensure they are suitable before entering service.



This could precipitate a major accident, due to the uncontrolled leakage of flammable solvent causing a fire or explosion with potentially serious consequences to the plant and the public.

To assure the safety of critical parts, examination following manufacture and throughout the lifetime of their use is necessary. As with traditional parts, Tony and his maintenance and operations colleagues need to understand what early signs of degradation they're looking for, and how best to monitor for them.

Experience of the use of traditionally manufactured parts over many years has brought an understanding of the appropriate checks and balances. This is not the case for AM parts.



Because Tony and his colleagues didn't fully appreciate the implications of using AM parts, they have discovered that, in an effort to find solutions, they have introduced new problems that could have been avoided with more careful planning and management of the potential risks.

Conversation Starters...

- ✓ Could changes in the nature of replacement parts mean that safety needs to be assured differently?
- ✓ How might the use of AM parts invalidate certification?
- ✓ Will standards need to be applied differently or different standards apply?

Summary of Challenges and Opportunities

Through the stories presented in this report, we have painted a picture of probable futures that contain many commonalities across important HSE sectors.

The work environment is constantly changing, driven by global drivers such as environmental and sociological factors - with adaptations in work organisation and tools.

Technology is increasingly being used within the workplace to: provide data to inform decisions; manage work; maximise efficiency; save costs and to monitor work tasks.

Some skill shortages are anticipated, and there is a need for workers to constantly learn and develop their skills. More people are likely to be working long hours and under increasing time pressures. There is a possibility that more people will feel isolated /disconnected from the equipment they use for work.

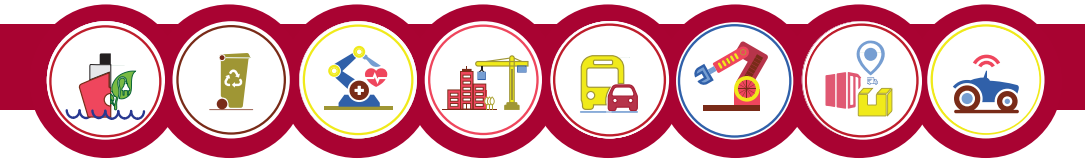
Technological advances are likely to support a reduction in the more physically demanding aspects of work.

The stories illustrate a future that offers both opportunities and threats to workplace health, safety and wellbeing – opportunities to reduce physical risks from work, but also potential for different ways in which the nature of work is changing to interact and create different / new challenges and risks.



? **Ask yourself:
'so what for me?'**

✓ *"What might these potential changes mean for health, safety and wellbeing in my area of work/interest?"*



FORESIGHT REPORT

The human impact of the changing nature of work



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