Automation and Sector Impacts Research 2016

Scottish Enterprise

optimat
strategies for success

Summary Report

November 2016

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Executive Summary

Over the years, automation has helped to transform our industries by carrying out tasks faster or more efficiently than humans, or performing activities that are considered dangerous and hazardous. We are now at the start of a new industrial revolution that is underpinned by machine learning and cyber physical systems with applications across all aspects of manufacturing and, for the first time, service sectors including the professions such as consultancy, legal and medical.

Developments in computing power and a range of digital enabling technologies are converging to enable the realisation of a new generation of cyber connected automation applications that will drive new manufacturing and service paradigms. These will provide opportunities for improved productivity, quality, speed of response, customer insight and services, and ultimately improved global competitiveness.

Business impacts can be categorised into four areas:

- **Productivity** – making things quicker, more efficiently and flexibly to increase global competitiveness
- **Innovation** – identifying new transformational solutions and applications because of technology convergence and new disruptive business models
- **Resource Efficiency** – reducing material wastage, returns and breakages and potentially lowering energy costs
- **Workforce & Skills** – improving workforce skills and engagement and delivering better and safer working environments, higher incomes and greater job satisfaction

This new generation of automation is likely to transform almost every sector of society, challenge our existing concept of work and redefine various tasks within jobs. It will also spawn new product and service opportunities that will generate wealth and catalyse new types of work and jobs.

In the **construction** sector, more buildings are likely to be constructed off-site in automated factory environments reducing the overall cost of construction while improving the quality and speed. On-site activities may be enhanced by automation to complement human activities and improve health and safety aspects. Exoskeletal suits will 'take the load' off workers carrying out physical tasks and new production technologies such as 3D printing for components and buildings will be increasingly used.

Financial and business services are already being transformed by the increasing use of software based artificial intelligence and automation. Driven by data analytics, business services will be improved because of a better understanding and forecasting of customer behaviour and needs. The high-street branches of banks may increasingly be replaced by online virtual branches that will become more personal in their behaviour as a result of improvements in artificial intelligence. In general repetitive and predictable tasks will be carried out by automation meaning that human efforts can be focused on higher value activities. This will include the provision of legal advice in selected 'non complex' areas.

The **food supply chain** could benefit from automation by using increased measurement, sensing and analytics to improve the productivity and yield of crops. Drones could be used to target and dispense nutrients where needed and agri-bots could be employed to remotely manage crops through the life cycle including picking of fruits. In food processing and production, increased use of low cost automation will improve flexibility and enable food producers to respond quickly to changing customer needs.

For all key sectors in Scotland, this new generation of cyber connected automation will have a potential impact. Solutions will be sector and application specific and this will require a deep understanding of a variety of technologies and their convergence potential combined with practical knowledge of the specific application. Increasing the awareness and understanding of automation for potential 'users' will be important so that opportunities can be identified and business cases made. Supply chain collaboration will be important as automation innovations will increasingly be across the sector and not just isolated processes within it.

Collaboration will also be important for the providers of automation solutions. This new generation of automation will comprise many different technologies and will require supply partnerships that change and evolve depending on the nature of the application.

Automation will have an impact on the nature of work and the tasks within selected jobs. A few jobs may be replaced, particularly those with simple repetitive tasks. But it is more likely to be the scope of individual jobs that will be redefined. Tasks within the job that are mundane, repeatable, physical or hazardous could be replaced by automation, freeing up time to do higher value work. This will ultimately lead to improved working conditions, health and safety and an increase in job satisfaction.

By 2025 automation is likely to contribute to net employment growth. New industries will be formed to provide and service new automation solutions, and within user sectors the company growth realised by automation will require increased employment.

For Scotland to effectively harness the potential of automation four key themes have been identified.

1. **Awareness** – raising awareness of the potential of automation among sectors, and also raising awareness of sector challenges to automation providers so that solutions can be developed.
2. **Collaboration & Networking –** of solutions providers to enable multi-technology solutions to be developed, and within user sectors so that supply chain solutions can be identified and developed.
3. **Innovation** – supporting the development of new solutions and reducing risk through demonstration.
4. **Skills** – upskilling existing staff for higher value roles, the development of future workers to provide automation solutions and upskilling of workers in user sectors to understand the potential of automation.

We have suggested a series of actions that can be carried out by industry, sector and technology intermediaries, academia and the public sector that will lay the foundations for Scotland to exploit the potential of automation in the next decade.

Table of Contents

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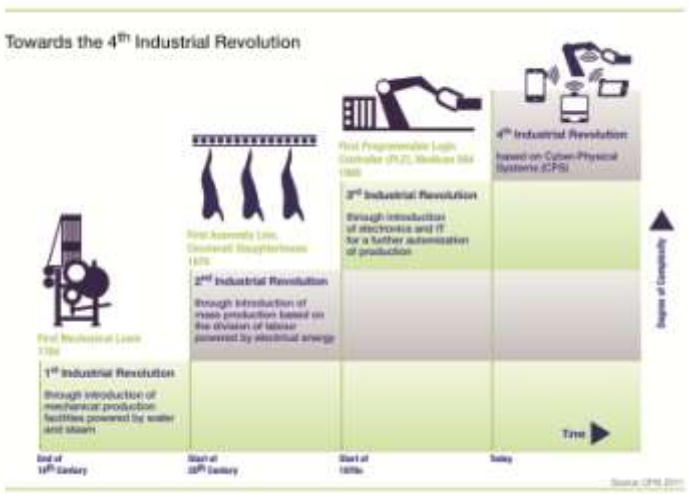
1. Automation - A transformational driver of change

1.1 Defining automation

Automation has been around since the time of Greek waterwheels. Towards the latter part of the eighteenth century, the introduction of steam powered mechanical machinery replaced repeatable processes carried out by humans such as weaving and catalysed the first industrial revolution. It wasn't until the introduction of mass production in the 1930's (the second industrial revolution), when the term automation started to become widespread. Robotics, in the form of robotic arms, didn't materialise until the early 1970's and this, alongside the adoption of advanced programmable logic controllers (PLCs) and ICT more generally across the global economy, characterised the third industrial revolution. Up until this stage the application of automation and robotic technologies had largely been for physical activities in manufacturing and production sectors.



Source: Used with permission of DFKI (German Research Centre for Artificial Intelligence)

We are now at the start of a new fourth industrial revolution, underpinned by machine learning and cyber physical systems and with applications across all aspects of manufacturing and, for the first time, service sectors including the professions such as consultancy, legal and medical.

This is a revolution that could transform industries into connected digital networks empowered by software robotics, data analytics and increasingly intelligent and autonomous robotics. It is the coming together of a wide range of technologies that will see the true power of automation unleashed to create new business models: manufacturing and service paradigms that will revolutionise the way we produce and consume. Additive layer manufacturing, distributed and networked digital factories, artificial intelligence (AI), complex vision systems and self-learning machines will underpin this new environment[1]. And with the service sector representing 78% of the UK's GDP, the potential impact on the economy is likely to be significant.

This report focuses on three sectors with potentially different automation characteristics namely; Construction, Financial and Business Services, and Food Supply Chain and considers how automation may impact them by 2025, and by doing so makes inferences to others key sectors for Scotland.

[1] We include an overview of the trends and developments in automation in the Appendices.

1.2 What is driving automation?

There are five main drivers that are aligning to fuel the growth of this new generation of cyber-physical automation technologies. Each of these is expected to be increasingly influential over the next 10 years and therefore will underpin any future vision of how automation will transform and impact on the Scottish economy and labour market. These are:

- The race for global competitiveness
- Labour market dynamics
- The increasing pace of technological change
- Technology convergences
- Falling costs

The **race for global competitiveness** means that companies must improve operational efficiency if they are to remain competitive. This means an increased focus on productivity and flexibility, both of which can be realised with automation technologies. Also, as energy prices increase it will become less cost effective to transport large and heavy raw materials, components and products around the globe. This will create new opportunities for distributed, networked and local manufacturing that offer potential to re-shore some of Scotland's manufacturing capability lost to low wage economies over the past 2 or 3 decades. Automation will be instrumental to realise this opportunity.

Additionally, and for the first time, the service industry will be increasingly exposed to opportunities arising from robotics process automation. Internet and cloud based technologies will allow service providers to be based almost anywhere in the world, and increasing AI and robotic process automation will enable higher wage economies to compete.

Labour market dynamics are also changing with people looking to improve their work-life balance and fewer people willing to take on manual and repetitive jobs. Automation has the potential to fill this gap and provide companies with a flexible production process that can respond to increasingly changing market demands. This brings challenges for employers in upskilling staff to manage automated processes and create business value in new ways.

In addition, there is ever-increasing pressure on employers to comply with more and more HSE legislation and regulation. Recent changes mean that Senior Managers are personally responsible for HSE non-compliance and can face fines or custodial sentences if deemed to be negligent. Automation and robotics are seen as solutions to isolate and protect people from hazardous operations and environments. Industries such as energy (oil & gas, nuclear and renewables), process industries and construction will see an increase in the use of such technologies as a result.

The increasing pace of technological change as defined in Moore's Law[2] has been a defining characteristic of the past 50 years. It states that every two years the power of computing doubles and the cost halves. This has resulted in an exponential growth of the computing industry to the point where we all have very powerful computers available at increasingly low costs. The computer is increasingly becoming a commodity with the value being in the software and the data it processes.

Ray Kurzweil of the Singularity Institute is a leading futurist who believes if current trends continue then AI will surpass the brainpower of a human by 2023. And by 2045 he suggests that we could build a computer that surpasses the brainpower of all humans combined. This vision of singularity may never be attained, but this increasing computer intelligence and exponential developments in machine learning will enable AI and robotics to increasingly challenge 'brain' based professions and not just 'brawn' based work.

In parallel with this increase in low cost computing power, and largely as a result of it, **technology convergences** are increasing opening up applications previously unimagined. AI is becoming so sophisticated that robots will increasingly be able to respond to, and learn, emotions. Combined with sophisticated vision systems AI provides robotics with the foundation to replace many human tasks. It is also forecast that robotics will learn at an alarming fast rate. Once a robot has mastered a process it can fully pass this capability on to others through networks. This is truly standing on the shoulders of others; humans have to start from scratch with every new generation.

Other technologies such as additive layer manufacturing (3D/4D printing[3]) mean that less human intervention is required to make components, with production processes increasingly compatible with digital systems. Improved communication and network systems will enable globally networked factories to become a reality.

The proliferation of low cost sensors is increasingly capturing data from a variety of sources and these previously disparate datasets are being combined to reveal new intelligence and improved value. The ability to interrogate increasingly large data sets quickly and efficiently in real time will see the rise of new on-demand services.

Finally, the fifth element that is driving increase use of automation and robotics is the increasingly **lower cost of hardware**. As in computing hardware, a rising demand for robotics will drive down the price of physical robots and this will catalyse increased uptake beyond the early adopters. The increasing value of data may even see automation hardware become a commodity that can act as an intelligence gathering source or a production outlet for branded products.

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2 There are signs that Moore's Law is slowing down, but growth is still expected to be significant (www.technologyreview.com/s/601102/intel-puts-the-brakes-on-moores-law/)

3 Current limitations such as slow pace, high cost and limited material options are expected to improve in the next 5 to 10 years

Developments in computing power and a range of digital enabling technologies are converging to enable the realisation of a new generation of cyber connected automation applications that will drive new manufacturing and service paradigms. This will provide opportunities for improved productivity, quality, speed of response, customer insight and services, and ultimately improved global competitiveness.

1.3 Current uptake in Scotland compared with other nations

It is often cited that the UK is under-investing in robotics and other forms of automation for manufacturing applications compared to other developed economies[4]. Robot density[5] appears to support this argument with the UK ranked as 22nd in the world[6] with a level that is barely above the global average, despite being the world's 6th largest economy. It is important, however, to recognise that manufacturing's share of economic output is higher is many of the leading economies than it is in the UK.

The UK's productivity performance is also at the lowest levels since records began, with UK workers producing significantly less per hour at 18 points below the G7 average, and a significant 36 percentage points behind that of Germany (the largest gap ever recorded with a fellow G7 country)[7]. The comparisons have also found that the UK productivity was lower than that of the US in almost every sector of the economy but that the biggest difference was evident in manufacturing. In addition, there is evidence of a sharp deterioration in UK productivity in the service sector including both financial and non-financial services since 2009.

There are many factors at play here and the reason for the UK's poor productivity performance cannot be placed solely at the hands of low investment in automation. But there are some who suggest that automation is closely linked with productivity performance[8] and that by 2035 national GDP will increase by over 40% because of automation, in both manufacturing and service industries.

However, there are signs for optimism. There is a view that the low investments in the past decade or so may work in the UK's favour[9], by allowing us to catch up with others who are still in the process of realising payback on previous investments.

In general Scotland reflects the rest of the UK with respect to automation deployment and productivity values. But it leads the UK, along with London, in recognising the potential of automation and Scotland and London are believed to be the regions most likely to invest in emerging automation[4].

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4 'Future Proofing UK Manufacturing: current investment trends and future opportunities in robotic automation', Mike Rigby, Barclays, Nov 2015

5 Number of robots per 10,000 workers

6 IFR World Robotics 2016

7 'UK productivity gap widens to worst level since records began'. Larry Elliott, The Guardian, Thu 18 Feb 2016

8 'The Future of Automation', Sam Korus and David Conway, Ark Invest, May 2016

9 'Press The Button', Ruari McCallion, The Manufacturer: Automation Supplement, 2014

The application of new cyber physical automation technologies in manufacturing and services offers Scotland the opportunity to address the productivity gap and underpin growth and increased competitiveness in key sectors. To understand the full potential impact of automation we need to understand how it may develop over the next 10 years and beyond.

1.4 Looking to the future

So what is likely to happen? There are two opposing schools of thought for this vision of the future.

The **Singularity Vision** takes the view that if current trends continue, advances in computing power and AI will create a cycle of exponential technological growth. This will result in robots that will be able emulate the way the human brain operates by around 2025. This will then trigger a runaway reaction of self-improvement cycles resulting in a superintelligence that will far surpass all human intelligence. The view of some futurologists is that this point of singularity will happen around 2045.

In other words, between 2025 and 2045 we will see self-learning robots with increased intelligence both intellectually and emotionally and with potentially many more 'human' physical attributes. In this extreme scenario, networked 'smart' robots would increasingly substitute for human labour, with some commentators suggesting that this world could happen by 2040-2050. It is a radical view and there are several balancing forces that could come into play to limit progress to this end.

- Polanyi's Paradox[10] states that humans 'know more than they can tell' and this will limit the ability of robots to emulate humans because they are programmed by humans. Contemporary computer science seeks to overcome Polanyi's Paradox by building machines that learn from human examples, thus inferring the rules that we tacitly apply but do not explicitly understand.
- Supply and demand will represent a self-limiting force on the replacement of humans in the employment chain. With no salaries being earned there will be no income to spend and therefore no demand for the products and services automation would be delivering. The concept of the Universal Basic Income (UBI) has been proposed to address this issue in the future.
- Ethical issues may limit progress. Just because we can create powerful machines with the ability to think and learn it does not mean that we will want to do this. This raises issues about regulating the development and application of AI that are currently being discussed.

It is a Dystopian view that appears to be more at home in a science fiction movie. But there are some lessons to be learned. Both agriculture and manufacturing were the earliest beneficiaries of machinery and automated processes, with both sectors now producing more that they have ever done in their history, and with fewer people.

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10 'Polanyi's Paradox and the Shape of Employment Growth', David H Autor, Sept 2014

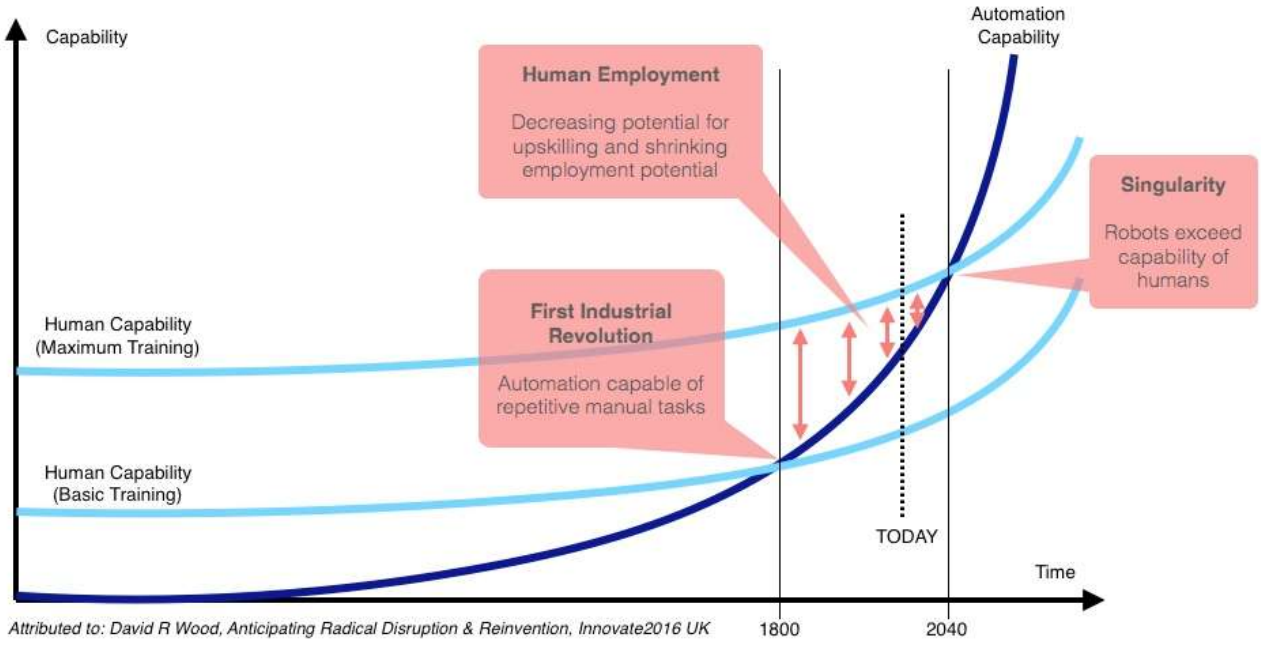
The **Experiential Vision**[11] adopts a more conservative approach that is based on the experiences of previous industrial revolutions caused by developments in automation. It is based on the premise that the application of automation will continue to stimulate economic growth which in turn will see an increase in total employment as a direct result of more globally competitive companies, new entrants and company expansion. Such a view recognises that employment in selected sectors will fall but that new unforeseen supply chain and business opportunities will appear that will more than compensate for such loss. It is a view that is easier to comprehend because it is based on proven historical trends, but there is a risk that it presents a rose-tinted view of automation and ignores its potential threats and underlying trends.

For example:

- Automation has historically affected lower skilled blue collar workers, which ultimately led to an increase in white collar employment and catalysed growth in the service sector. But with automation increasingly impacting on service sector employment, the question is; where is the new generation of jobs going to come from?
- Some experts[12] believe that as basic automation replaced the manual and repetitive tasks of lower skilled workers in the past, the natural option for workers was to upskill to increase capability and move into higher skilled work that automation could not carry out. However, with increasing robotic capability the potential for upskilling is reducing and therefore different employment strategies will be required in the future.

11 Optimat has adopted this term to reflect the views of many who look at past experiences of automation to make inferences on future behaviour

12 'Anticipating Radical Disruption & Reinvention', David Wood, Innovate2016 (InnovateUK and UKTI)



These two debates represent contrasting visions of how automation may reshape the future economy. In probability, the period up to 2025 may see both visions evolve as ethical discussions around technological advancements result in increased regulation of AI and machine learning applications.

1.5 Jobs v tasks

Our research indicates that for the majority of workers automation is less likely to impact on entire jobs and more likely to impact on the variety and nature of the tasks that make up these jobs. And this varies from sector to sector.

In the past jobs that were most at risk from automation were those that comprised of a narrow range of repetitive 'tasks'. In the manufacturing and agricultural sectors these tended to be repetitive physical tasks that automation could replicate with speed, quality and efficiency. Many jobs were re-scoped to include tasks that were more complex and where automation was less capable. This required a programme of up-skilling. As automation became more sophisticated because of technological developments, more job tasks were carried out by automation and this has resulted in a continual cycle of employment reinvention over time.

The service sector is now increasingly facing the same challenges posed by automation - as well as the benefits – that manufacturing has increasingly faced for the past 200 or so years. Largely as a result of robotic process automation (RPA), repetitive tasks will be increasingly automated and those jobs that are largely comprised of a limited number of repetitive tasks or

transactions may well be at risk. Upskilling will be required to safeguard these jobs and create new value for businesses, but other jobs will also arise to service these new opportunities.

AI and machine learning will affect both manufacturing and service sectors (including the public sector) as it will increasingly be able to replace a variety of more complex tasks.

Much of this is about timing. What we learn from the past is that we tend to overestimate the effect of technology in the short term and underestimate its effects in the long term[13]. Some experts believe that the pace of change will be relatively slow and more of a 'shuffle forward', rather than a 'march of the robots'. The OECD[14] argues that, in past experiences, new technologies are introduced slowly because workers need to adjust to new technologies and because new technologies create new jobs as well as replace existing ones. And McKinsey[15] state that although 45% of work related activities could be automated, only 5-10% of these will be by 2025. It goes on the say the remainder won't be jeopardised by the technology but they will be changed by them, indicating that it is the portfolio of tasks within jobs that will change in the next 10 years because of automation.

For us to determine the different impact that automation will have on the three focus sectors of Construction, Financial and Business Services, and Food Supply Chain, we need to consider how automation will help to carry out specific tasks within each sector.

13 Amara's Law, Roy Amara, President; Institute of the Future.

14 'The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis', Melanie Arntz, Terry Gregory, Ulrich Zierahn, OECD Social Employment and Migration Working Papers No 189, June 2016

15 'Help wanted: The future of work in advanced economies', McKinsey Global Institute, March 2012

2. A sectoral perspective - Future visions, opportunities and impacts

We have consulted with industry and key intermediaries to develop possible visions of the future for three sectors with different automation characteristics, namely Construction, Financial and Business Services, and the Food Supply Chain. The following represents *potential* visions, not predictions, set in 2025 for each of the three sectors to stimulate discussion.

2.1 Construction

The key elements of the 2025 vision are:

- An increasing share of the new-build housing market is taken by large highly automated offsite manufacturing. Upstream supply chain integration of construction product and component suppliers, co-located with offsite manufacturers, is increasingly common. Financial service companies have entered the market to establish 'mega-factories', similar to automotive plants. Consumers have reacted well to the high degree of customisation offered by this type of solution and the high quality of the build. Many traditional onsite trades companies are increasingly reliant on the repair and maintenance sector.
- Interoperability concerns about efficient sharing of data through the supply chain have been addressed and the use of BIM is widespread. This has enabled cost and productivity savings to be achieved and the quality of the construction output has increased.
- Health and safety performance onsite has been improved significantly through a combination of robotics to reduce workforce exposure (e.g. inspection and monitoring in hazardous environments), the use of onsite wearable technology to monitor health risks

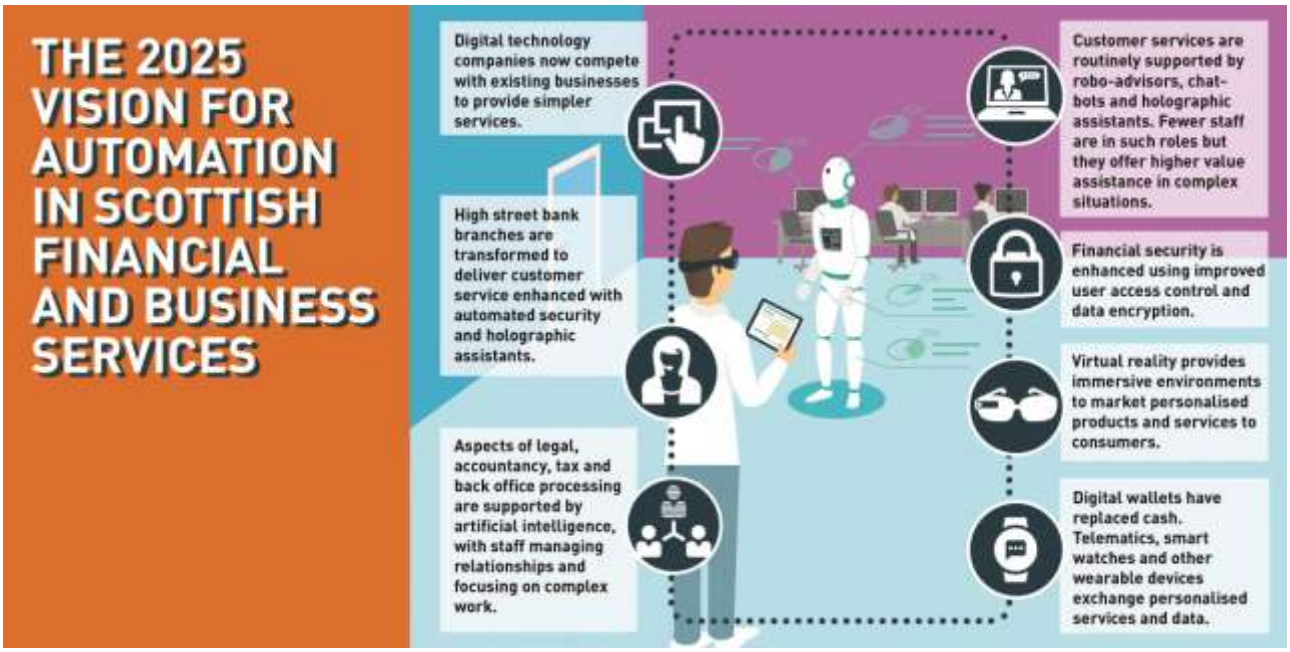
and tracking via GPS. The use of exoskeletal suits reduces fatigue, important to the ageing workforce.

- 3D printing of components onsite has enabled a degree of customisation not previously possible and architects are pushing the boundaries of design using new automated construction techniques.
- A local supply chain focused on automated inspection of assets has developed in Scotland servicing the construction sector and oil & gas, energy transmission network and wind turbine operators.
- 3D concrete and steel printing has been trialled on a small scale on a number projects but it is still a niche area of construction.

The high-level benefits and implications of this increased adoption of automation by the construction sector are:

- Significant increase in productivity for offsite manufacturers resulting from more efficient production processes and a reduction in post completion repair and remediation work.
- The sustainability performance of the sector has improved with higher levels of energy efficient housing in operation and less waste being produced at the manufacturing stage.
- Health and safety has improved across the sector with automation of infrastructure inspection, onsite worker tracking, use of exoskeletal devices and the move towards more activity being carried out in a controlled factory environment.
- Skill shortages for onsite trades, such has bricklaying, have reduced due to the fall in demand corresponding to higher levels of offsite manufacture.
- There has been an increase in demand for factory operatives and onsite assemblers as a greater proportion of the work has moved from site to factory.
- House builders offering high levels of customisation to consumers have been able use this differentiation to gain market share and obtain a premium over mass produced traditional build housing.

2.2 Financial and business services (F&BS)



The key elements of F&BS of the future include:

- An increasing share of the financial services supply chain is taken by digital technology firms. Following the success of Google's email money transfer and digital wallet services as well as Amazon's loan services for sellers[16], more and more new entrants have entered the market offering simpler financial services.
- There are fewer bank branches on the high street as branches have undergone significant transformation. The few branches remaining are now sleek buildings which reply upon biometric fingerprint scanning access as well as holographic assistants and smart walls to facilitate customer services.
- An increasing share of the legal services supply chain will be dominated by licensed, automated legal advice, sidestepping the use of human lawyers altogether for basic business dealings. These AI lawyers will predict the likely outcome of a legal dispute, helping companies decide whether to make the costly investment of hiring a traditional legal firm to apply a lawsuit.
- Customers have responded well to technology and utilise smart watches and wearable devices to connect to their F&BS provider. For example, to process transactions, to manage personal affairs and communicate with providers.
- Transactional security concerns have been addressed through improved user access control, multiple sign on and data encryption.

16 Computer Business Review (2016) Is Google Banking on Financial Services?

- Customer services include a combination of holographic assistants, robo-advisors and face-to-face assistance from personnel. Although staff levels have decreased overall, the personnel are more highly skilled and highly paid. Human support provides 'backup advice' in complex situations and/or when a customer requests specific human support.
- Service centres have evolved and are playing an increasingly important role in business, as they are now an integral part of business strategy, acting as a relationship hub rather than just a means for dealing with immediate problems. Work is now much more highly skilled, needing excellent communication skills along-side analytical problem-solving and project management skills. Customer service agents are adaptable to changes in technology, from becoming experts in apps and social networks to using an increasing range of data.
- Virtual reality continues to transform marketing and advertising as it enables brands to bring the reality of their products/services to consumers through personalised, dream-like worlds. Brands can now access the consumer's mind with no other distractions. Virtual reality is offering a whole new world of immersion and, as a consequence, audience engagement.
- There is less money in circulation as cash usage is low as it has become the least attractive method of payment; digital wallets replace money.
- Data analysis has enabled truly personalised services as previous behaviours are analysed, including spending and saving patterns, to offer tailored products and services. The focus is now on customers rather than products and services.

There are benefits and implications of this vision for both businesses and consumers including:

- Significant benefits for productivity and customer service.
- The competitive landscape is continually changing with more and more new digital entrants. As such, there is now a plethora of providers facilitating more choice for consumers.
- There is new and improved customer engagement, resulting in renewed trust between customers and financial services providers.
- There is a variety of new business models and processes available for service delivery.
- There is demand for increased levels of transactional security as millennial consumers are more tech-conscious.
- There is demand for data scientists and programmers in back-office technical roles in addition to a stronger focus on customer facing roles.
- Truly personalised insurance services are now possible based on real-time behaviour data and this customisation differentiates providers from one another. The provision of personalised services has enabled key players in the market to gain competitive advantage over mass service providers.

2.3 Food supply chain

The key elements of the 2025 vision for the food supply chain are set out below.

- The internet of things and the smart use of data has driven efficiencies in processes that were already highly automated (e.g. spirits production) to further eliminate downtime and maintenance issues, as well as support decision making for management and engineers. It also extends back to the farmer who is integrated into the wider process enhancing traceability and production planning for the whole supply chain.
- Robots have become simpler to use, they have fewer moving parts, can be easily updated and have controllers that can be integrated with other robots. Modular systems are commonplace, allowing increased flexibility in the production of food products. Robotics and automation provide the required level of flexibility to businesses that need to react to the changing needs of consumers and retailers.
- Robots and humans work together to perform a variety of tasks. These 'cobots' will not necessarily perform all activities in a process but will become co-workers, carrying out heavier, repetitive tasks alongside humans. This is due to vision and sensor technology developments as well as advances in computing power.
- Deep learning is being introduced in robots to eliminate the need for pre-programming to further simplify the use of robots in different applications (robotics manufacturer FANUC showcased its deep learning robot in Japan in 2015, which used trial and error to determine how to complete tasks).
- Farmers are becoming more like office managers. Given the significant level of technology integration, farmers are using real time data from several sources across the farm to make decisions related to operation of the farm e.g. sensors on cattle, sensors in field, drone data, weather modelling, etc.

- Small robots (agribots) are being used to autonomously scout, sense and treat invasive pests and pathogens and use micro amounts of pesticides and chemicals to treat crops. This means that less chemicals and pesticides are being used resulting in better tasting produce, reduced costs of production and more sustainable growing conditions.
- Fruit picking and harvesting robots are now available to reduce the significant labour requirements of these processes. Soft fruits are grown at a height that allows the robots to easily access the fruit. Although this is not yet widespread, it is an exciting development that is addressing a real need within the industry.
- Climate change, across the globe, has increased concerns over food security and Scottish researchers and businesses are capitalising on opportunities to develop new ways to grow crops:
  - Urban farming is becoming increasingly common to address shortages across the globe. This is also being carried out in a sustainable way by reusing heat from locally sited factories through collaborative arrangements.
  - Vertical farming has now been proven a successful alternative to outdoor food production and is a fully automated process, with minimal human intervention. Numerous facilities have been established across the country and are demonstrating excellence in research and development for Scotland.

The high-level benefits and implications of this increased adoption of automation by the Scottish agricultural sector are:

- Enhanced productivity from primary production processes and more flexible operations to address real time needs on the farm.
- Increased yield from farming operations due to the efficiencies created by automating processes and using (big) data to its full advantage.
- Increased profit for primary producers and hence the ability to reinvest in the industry and in new technologies at all stages within the supply chain.
- Significant reduction in pesticide and chemical use in agriculture leading to a reduced environmental impact for farming operations. This is also beneficial from a cost perspective as well as preventing further depletion of natural resources.
- A balanced approach between automation and craft/niche production has been maintained. This has always been particularly important for Scotland's vision of a land of food and drink. By automating time-consuming processes and mundane tasks, and introducing robotics to enable precision agriculture to flourish, famers can spend more time on key strategic tasks as well as using their time look after crops and herds better.
- Scotland has managed to enhance its reputation as a food producing nation and is now able to compete better in the global market place.
- Scotland is a leading player in research and development in Agri-tech and is demonstrating the potential to other nations interested in increasing their uptake of such technologies.

There are many high-level benefits and implications of increased adoption of automation by food manufacturing. These can be identified for both food manufacturing and for agriculture. For the food manufacturing sector these benefits are:

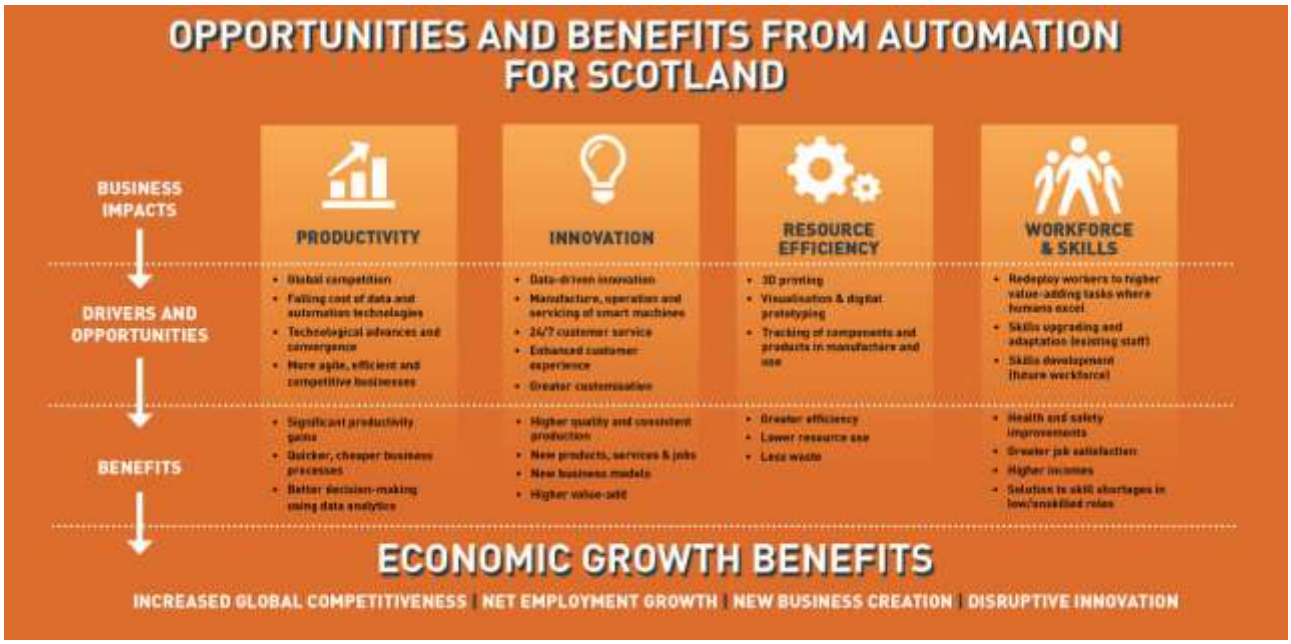
- The industry has become an attractive sector for young graduates to work in and this is enabling the adoption of robotics and advanced manufacturing.
- Productivity has increased significantly resulting from the increased efficiency in factory processes and the ability to operate both 24/7 and with flexibility when required.
- Businesses are able to comply with increasingly stringent regulations as well as meet demands for high quality products due to advanced automated vision inspection systems that are efficient and effective as well as control systems that eliminate human error and reduce human intervention. They also help to reduce waste and associated costs.
- The sector has continued to be one of Scotland's most important industries given its investment in automation, continually meeting global competitors head on while maintaining Scotland's reputation as a 'land of food and drink' with its natural larder and quality products.
- Businesses in the sector can reinvest in new technologies due to the increased efficiencies in their operations, creating additional opportunities for employment, upskilling and training of the workforce.
- There is a significantly increased awareness of the benefits of adopting automation technologies throughout the supply chain, with the biggest shift being in SMEs, many of which had previously been reluctant to invest.

3. Benefits and potential implications

3.1 Opportunities and benefits

Based on our analysis of the three sectors, we have identified four common opportunity themes arising from embracing the potential of cyber physical automation:

- **Productivity** – making things quicker, more efficiently and flexibly to increase global competitiveness
- **Innovation** – identifying new transformational solutions and applications because of technology convergence and new disruptive business models
- **Resource Efficiency** – reducing material wastage, returns and breakages and potentially lowering energy costs
- **Workforce & Skills** – improving workforce skills and engagement and delivering better and safer working environments, higher incomes and greater job satisfaction



The findings of our research and consultations with experts suggest that the ways in which these benefits can be captured in Scotland varies depending on industry. For example, specific automation solutions to increase productivity in construction will be different to those needed to increase productivity in the financial and business services sector. However, there are common implications and actions across a range of companies and growth sectors in Scotland. We will now consider the strategic implications for businesses, skills and the wider Scottish economy to identify the generic actions that we now need to address.

3.2 Potential implications

3.2.1 Implications for businesses

- Companies need to adopt a mind-set that embraces ongoing change as the speed of development and implementation of new automation solutions means it will be difficult to catch up when ground has been lost; a series of small progressions ahead of the game may be better than a large progression late in the game.
- Businesses may have perceptions of automation that are rooted in the past and which may be out of sync with the emerging reality. It will be important for business to understand how automation is potentially affecting new business tasks and processes.
- There is potentially a lack of in-house skills to identify applications that could benefit from automation, specify and discuss options with suppliers and ultimately oversee the procurement, implementation and operation of such systems.
- Automation will increasingly become a key strategic priority rather than an operational project and therefore management will need to understand its potential and emerging implications for their sector.
- Strategic collaborations will be important. This includes partnerships with automation suppliers who can understand their business operations and identify automation opportunities that they would otherwise be unaware of.
- Investment in automation will need to consider and include the human element such as upskilling, organisational development and staff redeployment.
- Funding automation projects may prove challenging in presenting the business case to investors / management, accepting risk and identifying suitable sources of support.

Business are about to experience a period of more radical and continual change in their operations and it is important that they have the mind-set, skills and partnerships to be able to exploit the opportunities that automation offers.

3.2.2 Implications for skills, jobs and workplaces

- It is forecast that in the next 10 years our accepted concept of work will start to be challenged as adoption of automation increasingly displace a wide range of tasks previously carried out by humans. Jobs, specifically the tasks that make up these jobs, will be redefined and our accepted working practice of 40-hour week, Monday to Friday, central office locations will be increasingly challenged.
- Re-skilling will be a key aspect of this new era. But with automation delivering increasingly complex roles this will be a challenge for the education system to prepare for the future.
- The education system will need to adapt to these fundamental changes to ensure that the next generation of workers are prepared for this new employment landscape. Future businesses will need more skills in areas such as digital know-how (technologies and their application potential), management capability (machines and people), creativity, entrepreneurship and complex problem solving. This will require a concerted effort from industry, the public sector and educational institutions.

- Increasing income inequality and polarisation in the labour market is already evident and these trends may become greater once automation starts to displace many repetitive tasks, typically done by lower-skilled employees. Income inequality will become an increasingly important issue for government to address.
- We are likely to evolve the deployment of people to tasks that humans are good at and which automation finds difficult i.e. jobs /tasks that require emotional, social and creative intelligence. As well as stimulating innovative, value-adding activities this could also drive growth in artisan and handmade products and represent a distinctive opportunity for Scotland.
- There is the potential for reduced working hours, and increased job sharing, with the benefits of increased leisure time and an improved work life balance. This is a claim that has been made since the 60's but, in reality, what has happened is that leisure 'time' has generally not increased but leisure 'opportunities' have. And providing these opportunities has resulted in the creation of many new jobs previously unforeseen.

The labour market is about to undergo a challenging period of transformation over the next 10 years, with the service sector being disrupted by an emerging portfolio of automation technologies.

3.2.3 Implications for other sectors in the Scottish economy

Aerospace, Defence and Marine

The aerospace, defence and marine sector is of increasing importance to Scotland and the Scottish Government has stated a strategic aim to support improvements in manufacturing excellence in the supply chain. Automation technologies that can help Scottish companies increase productivity whilst at the same time improving quality will ultimately improve competitiveness. Marine vessels will utilise autonomous technologies and by 2025 may have unmanned ships operating globally. An emerging space market will require increased automation and autonomous robotics both at a product and manufacturing level.

A global supply chain characterised by collaborative design, manufacture and assembly will require use of a range of digital platforms and technologies coupled with open standards and robust cyber security.

Chemical Sciences

This is a sector that is facing intense global competition and automation applications that can improve productivity and reduce cost will be a key focus for the next five to ten years. Removing people from hazardous environments and using autonomous systems that can predict and react to emerging situations will be important, such as intelligent asset management systems, involving drones that can access remote and restricted areas. This will ensure that the life of existing equipment/infrastructure is extended as much as possible, thus improving the overall productivity and cost base.

An increase in the use of sensors and associated data capture will provide the basis for a new breed of process analytics to be carried out to improve process control and quality. Real time, in-line and 3D measurement systems will underpin process automation in the future.

Creative Industries

3D printing and its offshoots will provide creative businesses with a whole new way to create and distribute products. Digital design technologies will enable the creative sector to collaborate globally and open new markets for niche specialisms. 3D visualisation will revolutionise the way that products are designed and prototyped prior to manufacture. With the manufacturing supply chain becoming more digitally based, the creative industries will engage more with manufacturers who seek product and brand differentiation in an increasingly competitive world. Increasing options to communicate and engage with customers in all sectors will open a plethora of new business opportunities in the creative sector.

Good design will be in high demand as this will provide the main area of differentiation between products. Similarly, hand-made artisan products are likely to experience an increase in demand.

Life Sciences

One area that has a lot of potential for the use of automation and robotics is the pharmaceutical and medical devices sector. This is because of the benefits of removing the human from the production process to minimise contamination and improve cleanliness. And as many of the tasks are repetitive and mass production oriented automation offers fertile ground for increasing process accuracy and speed.

Synthetic biology is another area where Scotland can build on emerging strengths. It will require high computing power to deal efficiently with the large amounts of complex data needing analysed for DNA cloning and sequencing, genetic constructs and engineering microbes.

Remote medical diagnostics[17] that could possibly be carried out using autonomous robotics could be used for remote populations. Using complex data analytics to match patient history, genetics and conditions to other matched patients from elsewhere worldwide who have reacted positively to treatment will realise personalised treatments that may be more effective than blanket treatment strategies. Scotland was also the first place outside the USA to carry out trials of orthopaedic surgery using robotics[18] and this is an area with potential that Scotland can build upon.

Energy

There are several drivers for the Energy sector in Scotland. In Oil & Gas the focus is on enhanced production techniques and the life extension of assets to ensure that the production of accessible oil is maximised. With production assets changing ownership there is a challenge to identify and understand the integrity of legacy and asset management systems. Variants of robotic process automation may be one option to measure and identify

17 http://www.io.tudelft.nl/onderzoek/delft-design-labs/applied-labs/ambulance-drone/

18 'Robotic Arm Trials at Glasgow Royal Infirmary', www.nhsggc.org.uk, 4 June 2010

performance trends and deviations so that appropriate action can be taken in advance. Activities in deeper and more hazardous environments will also require more remote, autonomous systems to be utilised and this will require improvements in wireless communications and mobile power systems.

For the renewables sector, maintenance and asset management is a significant challenge, especially for offshore operations. Systems that can automate the inspection, maintenance and operation of wind farms and tidal arrays will be increasingly required.

The nuclear sector is undergoing a plan of decommissioning that is likely to last well beyond 2025 and this will require sophisticated automation and robotics to deal with physical tasks that would be hazardous or lethally toxic for humans.

Removing the human from hazardous environments will continue to be a driver for automation and autonomous robotics throughout the energy sector.

Technology & Engineering

This is a diverse sector and one in which Scotland has strengths. It will largely be the provider of automation solutions; the automation supply chain. With tomorrows automation solutions requiring a multidisciplinary approach then collaboration and networking within this sector to develop new automation systems will be a key success factor. Scotland already has two Innovation Centres relating to sensors (CENSIS) and data analytics (The Data Lab) that are two components for solutions related to the Internet of Things (IoT) and working in partnership with sector oriented Innovation Centres such as the Oil & Gas innovation Centre (OGIC) and the Digital Health Institute (DHI) will be increasingly important.

But the sector will also be a user of automation. Precision engineering companies will use automated processes to provide around the clock machining services with self-configuring cells to respond to different components, materials and tooling requirements. High volume manufacturers will utilise robotics for fast, efficient and cost effective production. And bespoke and flexible robotics solutions will emerge for a variety of applications.

Textiles

The textile sector in Scotland has been experiencing significant pressure from low wage economies for the past 50 or so years. Competing on quality is an obvious strategy, not just in the quality of product, but also the quality of brand and service. As a result, there is an opportunity to meet an increasing demand for personalised, or lower batch run, clothing that will create a niche to differentiate Scottish companies. Highly flexible production machinery that is integrated into order, design and production control systems and provides a seamless and fast experience for the user will be important for the sector in the future.

Digital design that is inclusive of the customer, and automation technologies for marketing will be central to addressing customer needs. Sophisticated and flexible automation will be required to schedule, load and produce to order. Real time 3D vision systems will enable machinery to react to different fabrics as they progress through production.

Tourism

An important sector for Scotland and one that is already being transformed by automation, specifically robotic process automation. Companies such as SkyScanner are automating the process of researching and identifying suitable flight options and in comparing and selecting accommodation. This has transformed the industry and the services that travel agents provide. Tools are emerging that can automatically plan a holiday depending on duration, location and personal preferences.

There is the potential to use automation such as drones or remotely operated subsea vehicles to create new tourism opportunities such as virtual tourism and/or tourism in environments that are otherwise hard to reach or are hazardous, such as subsea, caves, mountains, etc. Telepresence robots may also be hired and controlled from afar and act as surrogates for personal travel.

It is important to adopt an application oriented view of automation versus a technology push approach. Therefore, the specific challenges of each sector and its processes will drive the portfolio of solutions that will be adopted. Cross cutting areas of interest will be awareness programmes, skills development initiatives and investment support.

4. Recommendations for action

4.1 Companies and supply chains

- Awareness
  - Improve awareness of the strategic implications of automation at a sector-by-sector level among business leaders and operational staff.
  - Support internal engagement with workers to communicate the benefits of automation and how it will improve working conditions, balancing the perceived negative consequences with an understanding of its positive effects.
- Networking and Collaboration
  - Identify opportunities to collaborate with the current and emerging automation supply chain to develop specific automation solutions to meet business needs.
  - Attend sector specific conferences and events to increase knowledge of emerging automation practices and to identify collaborative opportunities.
- Innovation
  - Raise the profile of automation within the innovation activities of the company.
  - Identify processes and/or tasks to pilot and adopt automation technology demonstrated elsewhere.
  - Invest in rapid prototyping and manufacturing technologies that will allow integration into a developing digital manufacturing network
- Skills
  - Improve technical expertise and understanding of the broad range of automation technologies and their application.
  - Develop entrepreneurship skills to identify opportunities for spin-out / new businesses.
  - Strengthen change management skills to prepare for and manage automation projects.
  - Enhance expertise in skills development and talent management.

4.2 Industry bodies and intermediaries

- Awareness
  - Improve awareness of automation and its strategic potential for their sector among their membership.
  - Hold events that connect automation suppliers with their 'sector' members to raise awareness of potential solutions and deepen collaboration so that automation suppliers can deliver innovative solutions.
  - Prepare and share sector-specific case studies to raise awareness of activity already happening elsewhere in Scotland and elsewhere.
- Networking and Collaboration
  - Chair and host Interest Groups comprising industry, innovation centres and academia to identify sector-specific opportunities and to develop a prioritised sector action plan.
  - Hold events exploring how automation can address sector challenges including presentations from the supply chain.

- Innovation
  - Understand the innovation support network relating to their sector / technology and signpost members to sources of innovation support.
  - For sector innovation organisations, carry out a series of pilots / demonstrators that the sector can engage with to witness potential benefits.
  - Strengthen collaboration between the Scottish automation research community and individual businesses to stimulate knowledge transfer and innovation.
  - Catalyse industry-academia collaborative projects related to automation that will benefit the relevant sectors.
- Skills
  - Prepare and deliver sector-specific training courses relating to automation and its potential, and how projects can be supported from identification through to implementation.
  - Work with businesses in the sector and in the automation supply chain to understand future skills requirements required for higher levels of adoption of automated solutions
  - Liaise with the education and training sector to determine future skills requirements which are expected to arise from increased adoption of automation solutions.

4.3 Public sector support

- Awareness
  - Increase awareness of the emerging potential of automation and how this relates to Scotland's growth sectors (e.g. case study development).
- Networking and Collaboration
  - Support conferences and networking events to raise awareness, stimulate networking and catalyse collaboration.
  - Catalyse a Scottish automation community by bringing together the intermediaries and research and innovation centres in the various disciplines related to automation
- Innovation
  - Develop sectoral automation visions to 2030 with technology roadmaps to accelerate research and innovation.
  - Consider options to exploit recent changes to GBER[19] to implement process and organisation innovation initiatives that will support the implementation of automation projects.
  - Support the growth of the automation supply chain in Scotland and solutions that will catalyse uptake in the recipient sectors.
  - Provide support to those seeking to adopt automated solutions (and encourage uptake among SMEs) through relevant support programmes

[19] The EC General Block Exemption Regulation (GBER) provides a legal framework for research and innovation support and changes in 2014 have provided more opportunities to support process and organisational innovation

- Skills
  - Promote better understanding of the likely implications of automation for education and training among Scotland's education and skills providers. This will help ensure that the future workforce is better prepared for the changing the nature of employment and demands for high-level problem-solving, relationship management and technical skills.

Appendix A – Technology trends and forecasts

Forecasting how automation will evolve over the next 10 years is fraught with difficulty with many top scientists and industrialists having different views. Almost all agree on the fact that automation technology will be an evolution, albeit a fast-paced one. The revolution will be in the emerging applications and new business models.

Within the next ten years we could expect the following developments[20]:

- **Collaborative Robotics** will be a transitional phase to fully autonomous robots and will be the biggest trend in the next 5 years and could be broadly available in 5-10 years. Nicknamed 'cobots', they will work in partnership with humans and carry out tasks that are not isolated behind safety screens. German car manufacturers are currently utilising cobots to keep baby boomers in employment longer by alleviating arduous physical tasks.
- **Autonomous Vehicles** will be more commonplace in industrial / agricultural applications and will be emerging into public transport by 2025. In the first instance, human supervision will be needed akin to cobots, but this is likely to reduce as confidence increases. First applications in the coming five years will be seen in commercial applications such as factory material movement and marine cargo transportation, and UK trials of driverless truck convoys are already taking place on the M6[21]. More automated public transport will increase post 2025.
- **Robotic Process Automation (RPA)** will continue its penetration into service jobs and some support tasks for manufacturing operations. In the next 5 years, RPA will find applications in service jobs with repetitive analytical / administrative tasks but with increasing AI this include more sophisticated jobs in the professional domain and will become commonplace in 5-10 years.
- **Artificial Intelligence (AI) / Machine learning** will become increasingly sophisticated and able to respond to more complex situations. This will place increasing pressure on tasks carried out by the professions in the next five years. In the next 5-10 years, we will start to see open sourced AI software platforms that will drive a multitude of new applications. Beyond 2025, developments in emotional and social intelligence within AI will see robotic interactions becoming more 'human' which may see increasing use in advice-related applications. This will raise ethical questions regarding the use of robotics in 'sensitive' applications such as child care and health care.
- **Digital Design** systems that are open and underpin the standardisation and exchange of design related information will be increasingly required to enable automation and robotic systems from various suppliers and geographic locations to interact. These are already availa**b**le in sectors such as Construction (Building Information Modelling) and will increasingly be used in other applications such as manufacturing to support globally networked digital factories.

20 Please refer to Glossary in Appendix C

21 http://www.bbc.co.uk/news/uk-politics-35737104

- **Humanoid Robots** will be available in isolated cases within the next 5 years but this will be for demonstration / engagement purposes only and for customer service type roles. They will become more commonplace in 5-10 years and by 2030 are forecast to be widely available. There will be increasing combination of AI and machine learning to give humanoid robots human-like expressions and reactions.
- **Non-Humanoid Robotics** will dominate and will take forms to suit the tasks in hand. This is because the application does not require robots to replicate a human form for engagement purposes, and will specialised for a limited number of applications.
- **Modular Robots** will start to appear in the next five years to address a need for process flexibility with 'building block' designs that can arrange themselves into pre-set patterns to accomplish specific tasks. With increasing AI, the need for 'pre-set' will reduce as robots are able to respond to challenges faced.
- **Telepresence Robots** will be available in a variety of forms that will be integrated into internet based communication systems such as Skype to act as stand-ins for users at remote events such as business meetings, concerts, medical and cultural and sporting events.
- **Drones** are already a rapidly growing area and are generally being used to access and visualise areas that are difficult, unsafe or expensive for humans to do so. But applications will increase from the 'entertaining' to the 'useful' and we will see a range of practical commercial applications. Logistics / product delivery applications are currently being investigated and trialled. Specialised drones will emerge to identify and resolve issues such as pot holes in roads, security breaches and agricultural/environmental monitoring.
- **Microbots (and nanobots)** will become more common place in 5-10 years. These will allow emergency responders to explore environments that are too small for larger robots / humans or too dangerous for humans. Networked intelligence of the 'swarm' will **compensate** for their relatively limited computational power.
- **Exoskeletons** allow users to augment their physical strength, helping those with physical **disabilities** to walk and climb. It will also find applications in the military and in applications where heavy lifting / activity is required such as construction and warehousing. These are likely to be adopted in a number of areas 5-years from now.
- **Body-machine interfaces** help amputees to feed-forward controls that detect their will to move and also provide sensorial feedback that converts digital readings to feelings. This will see significant improvements to prosthetics and exoskeletal systems that will realise the integration of the physically impaired into society and improve the functionality of exoskeletal systems for industrial applications.

To realise these technology trends and forecasts in automation and robotics requires developments in a broad range of enabling technologies. It is not within the scope of this study to cite them all but the following represent key areas that will underpin the growth and application of automation and robotics in the next decade.

- **Cyber Physical Networks** will be the framework that captures data, connects sensors, machines and people and will be the platform for a connected and collaborative automation environment. It will need further developments related to regulation, standards, open data and technologies that can ensure reliable connections.

- **Improved 3D (and 4D) vision systems** will be required to enable robots to engage and interact with their environment faster and more reliably. This will fuel developments in applications that are complex and dynamic and will enhance the effectiveness of autonomous systems.
- **Data Science** lies at the heart of robotic process automation (RPA) and will increasingly become more complex by connecting a variety of disparate data sources in real time to realise new enlightenment that will enable better and quicker decisions.
- **Alternative sources of power** will be required for applications that are off grid, utilising energy sources such as solar, wind and wave. This is already being investigated in the subsea sector for Remotely Operated Vehicles (ROVs) and will increasingly be applied to other aspects of automation and robotics in the next 5 years.
- **3D/4D Printing / Additive Layer Manufacturing** will become increasingly relevant to a broad range of applications. Advances in materials, coupled with improved 3D digital design and cheaper processes will be a key focus of the next five years and this will drive numerous new applications such as bespoke medical components, spare parts manufacture, and construction techniques and a move from mass customisation to total customisation. After 2025 3D Printing will become a mainstream manufacturing technology.
- **Robotic Super Muscles** involve improvements to strength that make them more compact and stronger than human muscles; allowing robots to outrun and out-jump humans. This will be driven by military applications in the next 5 years before being built into exoskeleton systems in 5-10 years.

The new generation of automation, robotics and autonomous systems will not work in isolation but will require developments in areas such as skills, regulations, standards, networks and collaborations as well as a portfolio of technologies and their convergence.

Automation companies tend to customise products for specific applications and sector needs, so innovation tends to come from applications rather than any new technology and therefore growth will come from totally new directions and models that are difficult to predict.

Appendix B – Bibliography/ List of sources

In addition to the footnote references to specific case examples and other evidence, the following sources were used to inform this report:

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Appendix C – Glossary of terms

Term	Definition
BIM	Building Information Modelling systems that utilise digital information about it physical and functional form throughout its life cycle and that enables supply chain collaboration.
Collaborative Robots (Cobot)	A robot designed to assist human beings on a specific task or process, and to work in partnership to carry out tasks that a human may find arduous or tedious.
Cyber Physical Systems / Networks	Systems and networks that link the physical world to the virtual world through sensors or actuators connected via the internet or using other wireless means. They are composed from diverse constituent parts that collaborate to create some global behaviour and include software systems, communications technology, and sensors/actuators.
Digital Design	A computer type of automation that allows virtual design and production of products, and that includes cost and performance data that can be updated automatically with changes to design specifications and shared throughout the global supply chain.
Drones	Unmanned air, land, sea, space vehicles in a variety of forms that can be controlled remotely and that may have a degree of autonomy but that can access locations difficult for humans.
Exoskeletal devices	Physical devices 'worn' by workers to reduce fatigue, reduce health and safety risks and improve performance capabilities beyond human levels.
Microbots (including Nanobots)	A miniaturised, sophisticated machine designed to perform a specific task with repetition and precision. Microbots typically have dimensions ranging from a fraction of a millimetre up to several millimetres. Nanobots are even smaller with dimensions in the nanometre scale.
Moore's Law	An observation made by Gordon Moore, co-founder of Intel, that the power of computing doubles every two years in parallel with the halving of cost. This is a rule that has proven to be true over the past 50 years.
Programmable Logic Controllers (PLC)	An industrial computer that has been adapted for the control of manufacturing processes, assembly lines and robotic devices.
Telepresence Robots	Systems that allow sensory data to be experienced and controlled in remote locations. This may be a humanoid robot that acts as a host for a human via an internet connection.
Universal Basic Income	A new social concept comprising a non-conditional income provided by the government to all members of society and that exceeds the recognised poverty threshold.

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