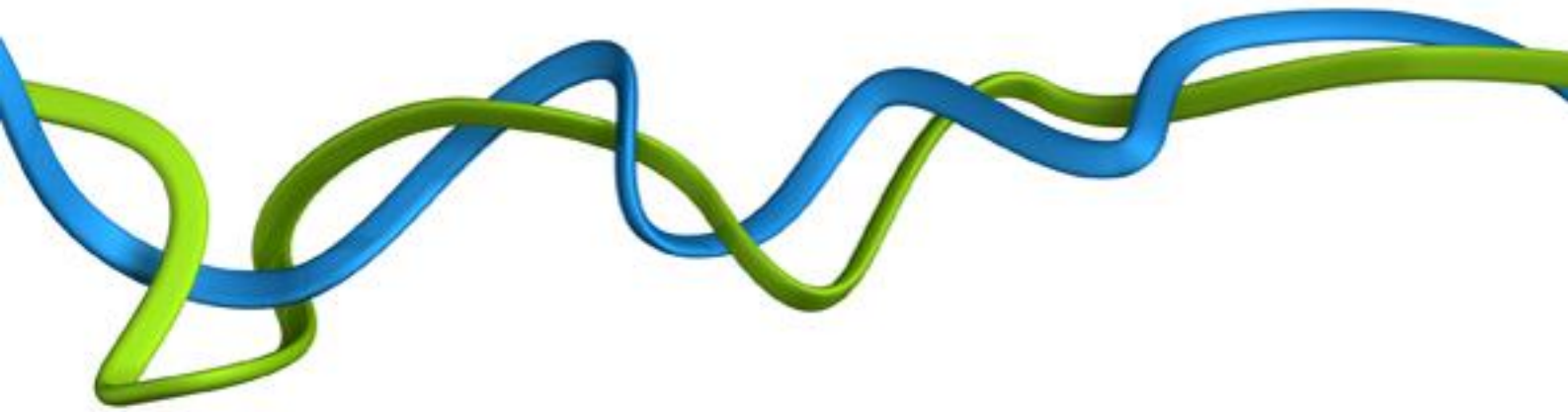
ROYAL ACADEMY OF ENGINEERING

Engineering the Future

Automation and the Future of Work

A response to the Department of Business, Energy and Industrial Strategy Select Committee joint inquiry on Automation and the future of work

July 2018



Introduction

We welcome the opportunity to respond to this call for evidence to the BEIS Select Committee inquiry into automation and the future of work. This is a cross-engineering sector response, produced on behalf of Engineering the Future, an alliance of the 38 professional engineering bodies in the UK. The response was led by the Royal Academy of Engineering with active input from:

BCS, The Chartered Institute for IT

Institution of Chemical Engineers

Institute of Measurement and Control

Institution of Structural Engineers

This response has been informed by the expertise of the Academy's Fellowship and the engineering profession, two roundtable meetings on the future of work hosted by the Academy in November 2017, and a workshop on robotics and autonomous systems, the outcomes of which were sent to the BEIS Future Sectors team.

Businesses

What impact has automation had on business productivity to date?

1. Automation has always been a central feature of the industrialisation process but has accelerated in recent decades. In manufacturing in particular, productivity has almost doubled over the last two decades as a result of automation[1]. Industries that have embraced automation, such as the automotive or pharmaceutical sectors, have shown significant increases in quality, productivity and production volumes. Prior to 2008 labour productivity averaged at 2% annual growth. However, since 2009 annual productivity growth averages to just 0.5%[2]. There are only a few highly automated, highly productive companies, and a much longer tail of companies that are less productive.

2. Between 1993 and 2007 automation is estimated to have caused a 0.37% increase of annual GDP growth, equating to more than 10% of total GDP growth for this period and without significantly affecting the number of hours worked[3]. While it is an important metric, GDP alone is an inadequate measure of the success of automation so other measures such as the OECD Better Life Index[4] will be needed. Additionally, new measures must be explored in order to measure improvements in digital productivity.

3. Opportunities for automation are being enhanced by recent advancements across a range of digital technologies which has resulted in concern about disruption to employment. Throughout the response the term automation is used to encompass a range of disruptive technologies including; autonomous systems, big data analytics (including artificial intelligence), internet of things, robotics, additive-manufacturing, machine learning and advanced sensing technologies. These technologies fit into two categories; digital

[1] https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/the-construction-productivity-imperative

[2] Office for National Statistics https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/labourproductivity/articles/ukproductivityintroduction/januarytomarch2018

[3] http://blogs.lse.ac.uk/politicsandpolicy/robots-at-work-the-impact-on-productivity-and-jobs/

[4] http://www.oecdbetterlifeindex.org

(automation of processes for example data mining, expert systems and medical diagnostics) and physical (autonomous vehicles, automated assembly lines and drones).

4. Productivity impacts will vary by sector. One example is the effect of distributed control systems and supervisory control and data acquisition (SCADA) on the process sector such as oil and gas installations and chemical plants, and infrastructure environments and utilities. Such systems have enabled teams of control and instrumentation engineers and technicians to be replaced by one or two operators monitoring an entire process. They have also enabled raw material efficiency to increase and processes to be optimised in response to changing market demand. The key to this ongoing change has been the development of intelligent sensors, and computer systems able to process the enormous amounts of data that result.

5. Greater productivity is not the only driver for automation. Other benefits such as improved quality and consistency of products, improved levels of personalised customer service, reducing energy use and environmental emissions, remote manufacturing and enhanced safety, are also important motivators.

Could automation lead to reindustrialisation as processes and products become cheaper?

6. There is likely to be some re-industrialisation but this will be quite different from the traditional production unit. Production and service provision will be localised and bespoke, with microproduction units producing items to order on an individual basis.

7. Automation could stop further deindustrialisation as the cost reduction associated with automation has the potential to allow UK-based facilities to maintain competitiveness against economies with substantially lower labour costs. In the future, whole life supply chain automation will dominate global manufacturing competitiveness and the UK must ensure it competes on a global scale in these terms.

Which sectors are most likely to be affected by a growth in automation? What sort of tasks are most and least likely to be replaced by automation?

8. Automation is unlikely to be at the level of whole jobs, instead the greatest impact is anticipated to be in the automation of sub-tasks which are routine and codifiable in all sectors. But there will remain a range of activities that are best done by humans. Humans and technology working together on a task will become commonplace. These partnerships will be flexible and aim to get the most from both the humans and machines.

9. Ideally tasks which are dirty, dangerous and dull will be automated but most sectors are expected to see disruption in coming decades. Some examples include: the service sector as taxi drivers are replaced with autonomous vehicles; healthcare with disruption from carebots, diagnostics and surgical robots; retail with online shopping reliant on automated warehouses; and financial and legal services where jobs are thought to be at risk from advancing data analytics. These changes will require varying degrees of human intervention in the decision-making processes.

10. Automation is not just a just a replacement activity; automation will enable activities that are currently impossible (e.g. deep sea mining) or cost prohibitive which may provide many economic benefits.

11. In its broadest sense automation is likely to affect all engineering sectors but some are anticipated to see more significant disruption in coming years;

    - Transport: automatic delivery systems on land, air and sea; intelligent rail freight; traffic monitoring and control; smart motorways and city through-routes.
    - Manufacture: a combination of robotics, additive manufacturing and CADCAM linked to intelligent databases will produce bespoke components and products.
    - Process industry: further automation of systems in hostile environments with the aim of excluding all human workers e.g. deep-sea oil and gas platforms, nuclear sites, hazardous chemical plants, mining and tunnelling. Some of these areas, such as mining, may have to change how they operate as mining a country's natural resource will no longer comes with the promise of jobs in the local community.
    - Construction: remote monitoring of the construction site; drones carrying out site surveys; building information modelling; 3D printing; augmented reality to understand design; AI to optimise cost and safety.
    - Agriculture: automation of planting, monitoring of animal or crop health, crop maintenance and killing of weeds and automated crop harvesting.

12. While there are many benefits associated with automation the linking of numerous intelligent systems with many complex interactions will also have risks such as widespread failures due to a loss of power supply or the recent banking data chaos. These risks must be considered when designing and implementing automation technologies.

Is there enough advice and support available for businesses who want to automate? Does the Government's Industrial Strategy offer the right support to businesses for automation?

13. It has been reported by some that there seems to be a general lack of awareness of what advice or support the government offer for businesses who want to automate. Apart from the Industrial Strategy White Paper there has been little promotion of technology in government.

14. Inclusion of a requirement to use automating technologies in the procurement of large infrastructure could support their adoption. Education for government procurers and organisations like NHS or Network Rail will be needed in order to encourage innovation through technology adoption. The skills agenda is highlighted in the Industrial Strategy but initiatives or funding to support change have been limited.

15. Industry needs to take a long-term view when investing in automation technologies, given the initial expenditure required. However, the allocation of government funding to aid technology advancement and adoption can be unpredictable, coming and going in cycles. Greater support for patient capital could be one way to overcome financial short-termism.

16. Automation could provide opportunities for productivity improvements and growth for many of UK businesses. However, for these technologies to be accessible and inclusive to all the businesses with the potential to benefit there needs to be an independent source of advice and support.

17. Such an initiative should provide explanations of disruptive technologies and the opportunities they bring, alongside relatable case studies of successful adoption. This would

have to be kept up to date to remain relevant in this changing landscape. However, it is recognised that this is difficult to achieve when best practice use cases are still emerging or may not be shared in order to retain competitive advantage.

18. The catapults can provide some support, with the High Value Manufacturing Catapult spending £14m pa of government funding on SME engagement allowing it to support over 4000 SMEs in 2017/8 financial year[5]. With their aim to enable the translation of new technologies, including automation technologies, from invention through to commercial exploitation, Catapults could play a significant role in increasing productivity.

19. SMEs could potentially be further encouraged and assisted to automate by forming 'partnerships' with the larger companies in their supply chain. If there is a strong commitment by the large purchasing company to a long-term relationship with visibility of contractual commitments, it may be enough to persuade their SMEs to invest in automation which ultimately would be a win/win for both parties. Additionally, some businesses could usefully be connected with universities that have specific expertise in areas where they have a need. The need for good brokerage tools to help universities and businesses identify and connect with suitable partners has long been recognised, and was the focus of a recommendation in the Dowling Review of Business-University Research Collaborations. The creation of the innovation brokerage tool Konfer, is a welcome development. However, it is also important to note that businesses do not only require an online matching service, but an integrated package of support which can help them to identify potential partners and provide a guide through the maze of different agencies providing funding support. In addition, the outputs of such a service need to be accessible to non-specialist audiences. However, the financial pressures on universities are substantial and as a result they are perceived as being pushed towards quick wins which mitigates against SMEs where cost-to-serve (same as for the Catapults) is substantial.

20. Importantly, the ability for an industry to automate also depends on access to the skills needed to define system requirements, implement, run and maintain the technologies. This will require access to capable system integrators with sector specific expertise as well as access to staff to purchase, maintain and operate systems. Many SMEs do not even have enough basic digital skills, so for them automation will prove even more difficult.

21. Automation will displace employees from traditional jobs. It is incumbent on government to provide the necessary funding and industry to provide the necessary training to upskill displaced employees so that they are able to take on the higher skilled, higher value jobs created by automation.

What opportunities are there for British tech businesses from a rise in automation? How can these opportunities best be exploited for the benefit of British industry?

22. Economic potential from increased productivity can have a wider benefit for the UK. Given that the rest of the world is adopting these technologies we cannot be left behind. Failure to do so will have a detrimental effect on competitiveness.

23. <u>Commercialisation</u>
The UK has the opportunity to capitalise on these new markets as well as increasing the productivity of existing industries.

[5] HVM Catapult quarterly report May 2018

24. There is a general view of the UK that it is strong on research but comparatively weak on development, demonstration and diffusion. The UK's universities and innovative SMEs have strengths in smart manufacturing processes, intelligent networks and big data analytics. However, commercialisation of these ideas is limited by a number of factors which could be overcome with increased support for adoption. An initiative, such as a national programme, to demonstrate and educate business leaders on the potential opportunities from automating technologies could improve their uptake. Such an initiative could increase the demand for automation locally, where encouraging partnership working between the technology developer and the manufacturer could be beneficial for both parties. Knowledge Transfer Partnerships worked well in this regard for those that participated.

25. Automating technologies such as measurement technologies, manufacturing execution systems, cyber security, robotics and autonomous systems, and data analytics have been identified as having a significant opportunity for innovation and expansion.

26. <u>Regulation</u>
    There is general agreement about the need for regulation of advancing technologies to ensure safe operation for users and avoid negative environmental consequences. Good regulation, that ensures safety without inhibiting innovation or deterring investment, has the ability to make and shape markets. This regulation will need to be international and agile so as not to cut off innovation, with regulators working alongside industry to ensure they remain up to date with continuing technology advancements.

27. There is an opportunity for UK to help define the wider regulatory framework for a global market, giving preferential market access to the initiating country's industry. This may be important in order to maintain influence on regulations and standards following Britain's exit from the European Union. By defining good regulation, the rest of the world is likely to follow, therefore regulators should be encouraged and financed to collaborate internationally wherever possible.

28. The UK has a number of sector-based regulators with national responsibilities. These regulators are restricted to their narrow sector and are largely based on regulation of human behaviour. In contrast automating technologies, such as autonomous systems, can have a major cross-sector impact and in many cases will replace the human decision making so will need to be regulated in terms of the ethics and correctness of the decision. Regulators will need to understand the potential consequences of these technologies and must be required to work together, communicating both across and within sectors. There are potential gains to be had from cross-modal applications in areas such as transport to create a competitive advantage.

29. The UK regulators must liaise closely with the international community as this is critical to open new markets and maximise export opportunities for the UK. Regulators need to be equipped to deal with these new technologies across all sectors. As such the skills and expertise of regulators will need to be enhanced. This will require engineering, social science and human factors specialists to assess and regulate technology and its interaction with the wider population. Regulators should be encouraged to draw on skills and knowledge from industry, especially SMEs, to align future regulations with technology developments. Regulators must be provided with adequate funds to pay for this support as it will be advantageous for UK industry.

30. The government has proposed a move to regulation around ethics of artificial intelligence ethics, which is likely to be needed. This should include a consideration of algorithmic fairness, for example people should have the right to understand broadly what criteria were used if a machine is making an important decision. In addition, if artificial intelligence is to be a success, access and control of data will be important and must be managed correctly in order to ensure its value is realised.

31. Infrastructure
The government should also ensure the necessary infrastructure is available to support the adoption of new technologies. We cannot predict how these technologies will advance in coming decades. Infrastructure typically has a much longer lifecycle than its occupants and it is therefore important to build in flexibility and adaptability to support technology developments (e.g. Air Traffic Management for increases in drone traffic; highway infrastructure for driverless cars).

32. Increased use of automation technologies will require secure, high speed broadband access as well as increased electrical power, this infrastructure must be accessible across the UK.

Workers
Are there specific demographic groups most at risk? How far can these be mitigated by new roles in these industries?

33. Work has already changed dramatically in the last decade with increasing zero hour contracts, self-employment, part time and agency work while job security has decreased. Automation will change work further and careful consideration will be required to avoid increasing inequalities in terms of age, class, gender, education and location. If not considered, there is a risk of reinforcing inequality where it already exists.

34. Unlike previous phases of automation both blue- and white-collar workers are likely to be affected by the fourth industrial revolution. However, some analysis suggests low wage jobs may still be more likely to be automated, potentially furthering existing income inequality[6]. Increased regional inequality could also be a risk as the areas in which the majority of the technology is developed are expected to experience less of the impacts when it is deployed[7]. It's not just where, there is also the question of who is developing the new technologies. It is already the case that gender and age diversity in start-ups is very low, increasing the risk of bias or the products developed not being inclusive for all users.

35. At the same time, where automation is designed and implemented well it can improve productivity, job quality and create more skilled and higher paid jobs with added social benefit. The benefits from improved productivity can create opportunities for expansion and therefore job creation. With the right support including education, infrastructure and diversification of the technology workforce the negatives can be avoided and these benefits can be realised.

36. Automation provides opportunities to improve the conditions of workers who provide crucial human-to-human interaction. By automating very physical or repetitive tasks more time can be spent on the human tasks.

37. Provision of digital infrastructure such as fibre optic broadband in all parts of the UK would enable innovative business to be established anywhere they choose.

[6] IPPR (2017) Managing automation: Employment, inequality and ethics in the digital age
[7] Centre for Cities (2018) Cities Outlook 2018

38. Increasing digital skills across the UK and encouraging more diversity in those developing the technology may help reduce some the negative effects of automation. With the right planning and education system there can be opportunities from automation. Analysis for Northern Ireland suggested that a net increase in jobs could be possible - while around 400,000 jobs could potentially be lost 600,000 could be gained[8]. However, getting the right approach will be vital to manage such significant shifts in employment.

39. Continuous training and retraining throughout an individual's working lifetime will be increasingly necessary. There will have to be a shift in the education system in order to support lifelong learning.

40. It is important to consider the whole working population who fall on a spectrum from those whose identity is defined by their career to those for whom work is just a means to get paid. Without gaining a true understanding of individuals' ways of working and drivers we are in danger of making incorrect value judgements.

What are businesses doing to offer training to staff, either as a result of or in support of automation? Should Government have a role in retraining workers affected by automation?

41. It will be important for companies and government to offer reskilling for those affected by automation to support them through the transition. We may need to help a taxi driver become a call centre worker or a machinist to become a coder. There may be many new types of roles available, but those affected by automation are likely to be the least able to support themselves through the transition without proactive support.

42. A retraining/upskilling culture is not commonplace in the UK – in 2011 participation in employer-led training was just 25%, one of the lowest rates in Europe. This proportion had declined 10% from 2007, a shift in the wrong direction given the automation trend. Currently UK employers spend less on in training than other major EU economies and less than the EU average[9]. Tax breaks and other incentives are largely responsible for this trend in the rest of Europe. Government must support employers to retrain their staff and by taking a role in upskilling the workforce and providing general training for in-work staff, to ensure they will be able to carry out the high value-added roles which increase the efficiencies post-automation.

43. Some industries are engaging their workers in their 10-year automation plans offering opportunities to upskill/retrain for both hard and soft skills. SMEs can find offering similar retraining opportunities difficult as support is fragmented and there can be a lack of connectivity for SMEs to engage with existing funding or training systems as well as with larger industry. Again, SMEs and larger companies could use a 'partnership' model within their supply chain in order to share the capacity for skills re-training.

44. These reskilling opportunities need to include both soft and hard skills, and support to understand how an employee can transfer their existing capabilities to a completely new field or sector. These need to be accessible to everyone and supported by government. Abilities and skills that are currently uniquely human will be crucial and must be valued. Communication, creativity, problem-solving, systems thinking and teamwork are among those anticipated for 2030[10]. These skills are part of engineering's habits of mind[11] and

[8] http://connect.catalyst-inc.org/research

[9] Chartered Institute of Personnel and Development (2017) From 'inadequate to 'outstanding': making the UK's skills system world class.

[10] NESTA (2017) The Future of Skills: Employment in 2030.

[11] Royal Academy of engineering (2014) Thinking like an engineer.

government, alongside the professional engineering institution and industry, should look ahead to ensure that graduate engineer training meets the future needs of the industry.

45. The professional engineering institutions should also be able to flexibly deal with new jobs and careers arising in the near future. They must also inspire, inform and motivate the reskilling of those sections of the workforce carrying out low-added value repetitive tasks that can be carried out by machines, as well as ensuring there are more opportunities for non-engineers to enter engineering careers later in life with targeted support such as bursaries, scholarships for foundation programmes and/or degree 'conversion' courses. In the future, it will be increasingly important for engineering to be able to import skills and expertise through conversion courses for those who were previously on a parallel career track. Professional engineering bodies will have an important role to play in considering how to ensure that standards and competencies are met.

46. There is a major digital skills shortage caused by the challenges of the education system to adapt at the same rate as technology. It is hard for educators to keep up to date with technology that is moving so quickly so it is important that government enforce continual development for teachers and put funding in place to support this. However, a narrow focus on short-term technical skills will not suffice.

47. For those whose jobs are lost, it can be difficult to identify their natural skills and how they can be applied in a changing job market, more support may be needed in the transition period.

What other actions should the Government be taking to support those affected by automation, such as a 'robot tax'?

48. Previous industrial revolutions have not resulted in mass unemployment. If this time it is different, as some analysts suggest, and jobs losses occur at much higher rates there will need to be a wider debate on the future of fiscal instruments such as taxation. This could require consideration of more radical interventions, for example a potential shift from taxing work to capital, including inheritance and properties, universal basic income or the possibility of rent on automation. However, the government should be very cautious of disincentivising the automation of laborious work, and by association investment in manufacturing efficiency and increased productivity, through measures such as a 'robot tax'.

49. Instead the government should be proactive in mitigating these effects through full utilisation of productivity enhancements from automation systems and a combination of high investment in training for in-demand skills and reduction in working hours for those with high-demand post-automation skills.

50. Debates about these topics should be had early, engaging the public in dialogue. This could be achieved through open and transparent conversations. There may be additional benefits by providing access to a set of acknowledged experts who can engage in public dialogue with press and legislators to help the dissemination of facts and well-founded evidence.

51. Furthermore, a rethink of the role of the digital citizen is needed. A new approach might consider both the rights and responsibilities of consumers, rather than solely the rights[12]. This would allow us to redefine the idea of work, take ownership of our personal data and address regional or generational inequalities.

[12] Dr John Lazar CBE FREng (April 2018), *Rebooting citizenship: responding to AI and automation*, paper for Fourth Group.

52. Education
    The government has an additional role to play in ensuring the future workforce are equipped with the skills needed in the fourth industrial revolution. There is already a recognised skills gap. Technical skills at all levels are needed; from PhD level technology experts to apprenticeships with the skills needed to deliver technologies on a large scale to diverse markets.

53. In schools the focus needs to be on creative problem solving, collaborative working, communication of ideas and critical thinking. We need to be creating a population who are agile and adaptable in order to respond to the changing demands of the job market.

54. Organisations such as the Manufacturing Technology Centre (part of the High Value Manufacturing Catapult) have established an apprentice training centre, specifically to train apprentices in the new high value manufacturing technologies such as automation with just 100 apprentices joining the programme each year – this is too few to meet demand and the model could be repeated to create more regional centres with the same objectives.

55. 70% of the future workforce has already left education so prioritising life-long learning initiatives will be a critical step. Many jobs which survive in the short term will involve human interaction with a customer such as hairdressers or plumbers so emphasising and improving the prestige of appropriate lifelong vocational training alongside opportunities for more technical up-skilling.

56. The E4E response to the Education Select Committee inquiry into the Fourth Industrial Revolution highlighted that increased digitisation is already facilitating learning delivery via alternative forms, including MOOCs. Research by the Open University (a leading provider of MOOCs) has revealed that the number of participants indicates that access to education is widening, but this is in fact a false measure: most participating individuals already have prior experience of higher education. Although 13-17% of MOOC learners have some form of disability, this is lower than the proportion of the UK population with a disability (22%) and indicates that work needs to be done to make alternative forms of education in the Fourth Industrial Revolution fully accessible to all. Course design must take into account points at which learners are likely to need support to raise course completion rates (currently around 10%). Technological innovations – for example, the development of gamified learning resources – may enhance motivation among participants, as well as accelerate learning and keep up to date with technological advances.

57. People will need support in identifying new career directions, getting them back into college for a limited period will give them access to contacts, advice and a support group.

58. Regulation for public safety and trust
    The technology developed must be safe for workers and consumers to interact with.

59. For complex automating technologies the associated standards and regulations need to be considered globally. The UK must continue to be involved in the committees developing these international standards and regulations. Within the UK, regulatory thinking needs to be cross-sectoral while fitting within existing frameworks.

60. Public trust can be influenced by regulation, widespread integration from trusted brands and the media. Good regulation and public trust are synergistic, one encouraging the other. By taking steps to introduce broad legislation there is an opportunity to instil confidence regarding safety and reliability. This increase in confidence may make workers more comfortable with the idea of working alongside automation.

Consumers

What are the potential benefits and disadvantages for consumers of businesses increasing automation?

61. Quality
    Automation may bring an increase in product quality and consistency, which can be a matter of consumer safety in chemical and pharmaceutical industries. Use of automated data analytical processes can result in better informed design solutions, and a greater consideration of human factors will yield insight into beneficial and harmful designs. There may also be improvements on time delivery and responsiveness, however, if roles involving direct interaction with customers are automated there may be a reduction in service quality.

62. Reduction in cost
    With increased productivity and reduced material waste in manufacturing, products should become less expensive to produce and these cost savings could be passed on to the consumer. As disruptive technologies bring down costs for the consumer they can have detrimental effects on the wider system, as demonstrated with Uber increasing city traffic.

63. Personalisation
    Advanced manufacture, Internet of Things and other technologies can create opportunities for personalised solutions, from medical treatments to controlling your washing machine remotely. Consumers will also build up automated systems out of products for example an automated house alarm system which carries out facial recognition and tells the neighbour if you are away and the person is unknown. Simultaneously, other services may become more standardised as they are delivered by machines which may not suit everyone.

64. Health and Safety
    As with any new technology we must recognise that there will inevitably be good and bad consequences as well as genuine mistakes and system failures. In the long term, fewer accidents are expected with automation than with humans, but there will be a transition period in which the public may be more sensitive to technological failures than human ones.
    The aim must be to ensure that technologies are, and are seen to be, developed in a responsible manner to gain public trust. It is important that ethical implications are considered from an idea's inception. To ensure this, ethical standards must be developed and appropriate training delivered to those involved in the development and implementation processes.
    There will be those who embrace the advancing technology and who abuse it and systems need to be safe and resilient to any attacks.

65. Quality of life
    Assisted living and autonomous vehicles will give people more freedom but may also reduce the number of human interactions. Smart homes enabled through the internet of things will allow decisions at home to be made remotely allowing more flexibility. Consumers are also likely to be able to increase their personal efficiency and productivity as a result of automated processes.