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Artificial intelligence: What it means for the built environment

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Report for Royal Institution of Chartered Surveyors

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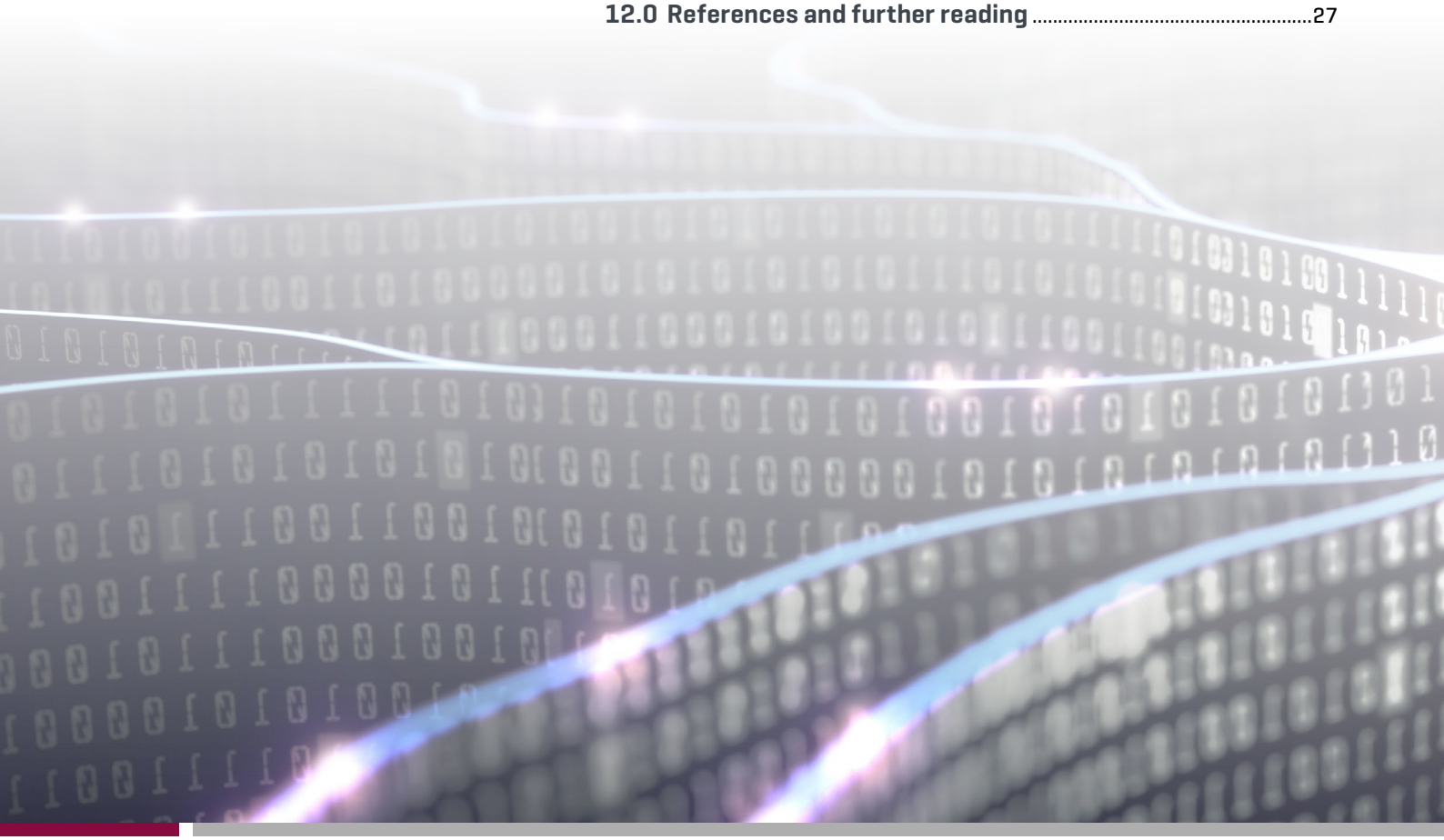

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Abbreviations

AI	artificial intelligence
AGI	artificial general intelligence
API	application programming interface
BIM	building information modelling
BSI	British Standards Institution
CAD	computer-aided design
FM	facility management/facilities management
GPS	global positioning system
IFC	industry foundation classes
IoT	internet of things
ISO	International Organization for Standardization
PDES	product data exchange specification
SaaS	software as a service
STEP	STandard for the Exchange of Product model data

Executive summary

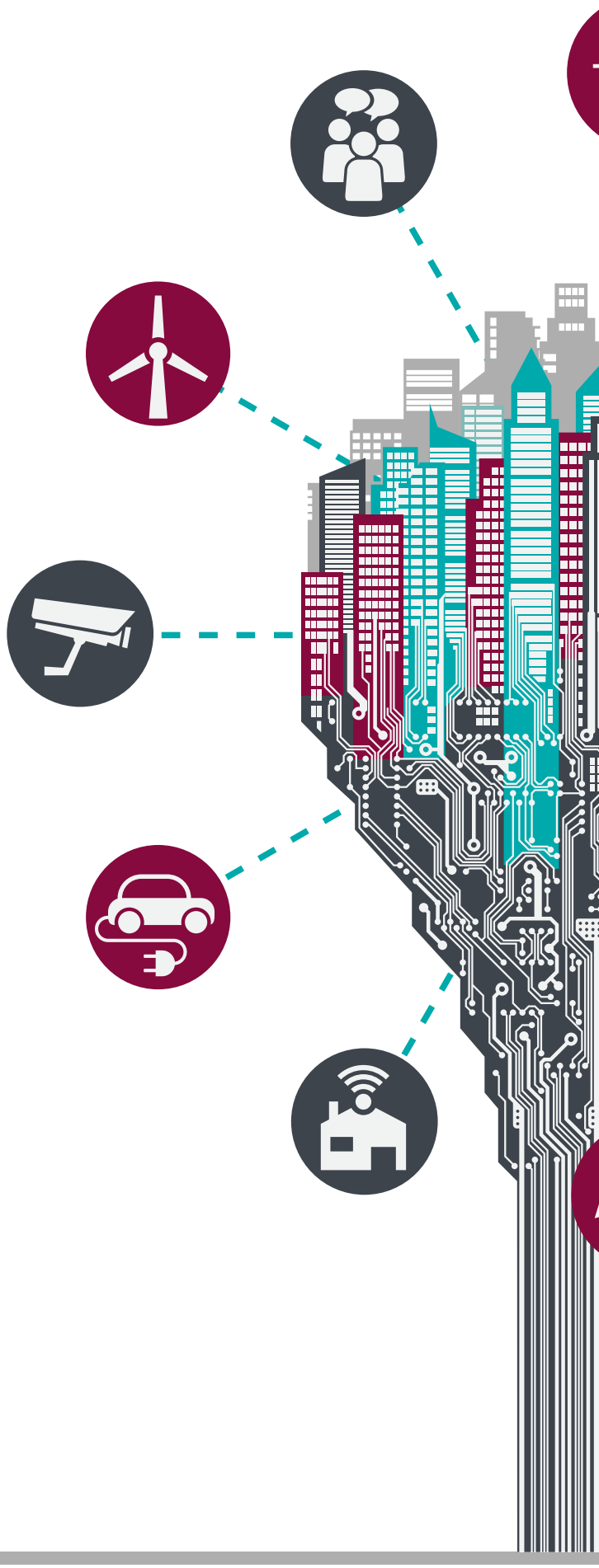
There is technology and there is highly disruptive technology.

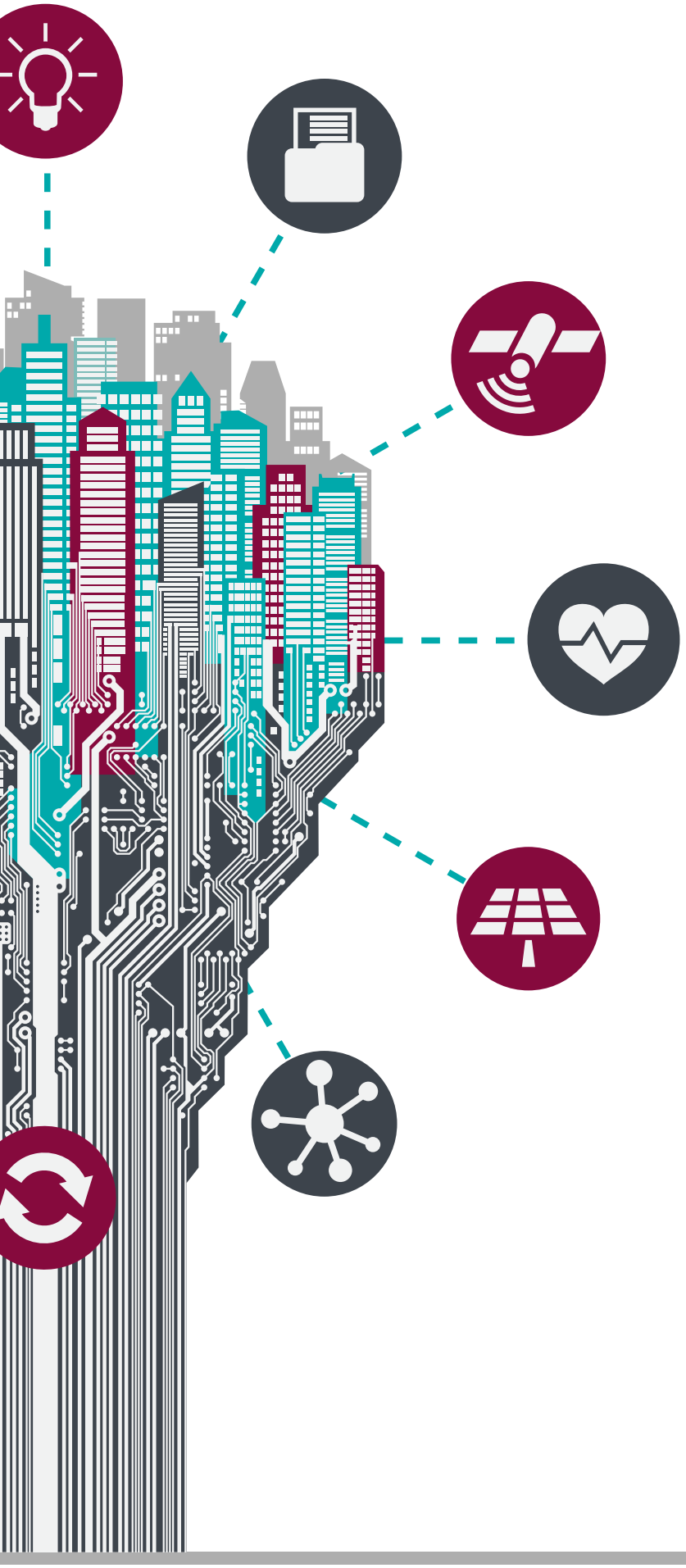
Artificial intelligence (AI) stands apart from the innovations that we have become used to in our daily lives and in our work. Decades of steady and sometimes staggering improvement in information and communications technology have already changed how most of us do our work and interact with others. This technology has replaced many inefficient and non-value-adding processes, creating new business opportunities and even entire industries.

The pace of change is about to quicken as AI finds its way into aspects of work and life that were previously off-limits. AI represents a major step change that will impact everyone to a greater or lesser extent. Governments, NGOs and major corporations are making plans for a world in which intelligent machines and systems will reduce dependency on the human workforce. For those engaged in creating and sustaining the built environment, there are threats from a technology that can increasingly outperform the physical and cognitive skills of workers on all levels.

There are also real opportunities for those who can understand the changes that AI will bring for the better and who are then able to exploit them. There has been, and will continue to be, a certain amount of hype and scaremongery because AI will have a profound impact on employment, society and the global economy.

This paper examines the current thinking, state-of-the-art applications and predictions surrounding AI to uncover many examples of how it will transform the way we work and how we can exploit it to improve the quality of the built environment. From the design and construction of a building through to managing and maintaining it, AI is increasingly being integrated into core business strategies and impacting the work of surveyors of all disciplines and their fellow professionals. Accepting that the future will increasingly see more reliance on technology in general and less on human labour and basic skills is the first step. Developing an objective, balanced plan to exploit AI is a close second.





1.0 Introduction

Artificial intelligence (AI) has become a topic of considerable debate, with positive and negative implications promoted and challenged by a broad cross-section of interests and individuals. Many claims have been made; some are wild exaggerations, others are more measured and cautious. We need to understand what this technology can do now, what is probable in the foreseeable future, and the actions that might have to be taken to deal with it.

The research for this paper is based on information and data collected from multiple sources, with the aim of presenting a balanced set of arguments and perspectives. These in turn help to map out plausible scenarios and responses. The paper begins by discussing developments in AI and how they will impact the socio-economic landscape, business in general and the built environment, particularly the professional and other services that create and sustain the latter.

2.0 What is AI?

In the late 1980s, a group of leading industrialists and academics discussed their vision of the future for the UK's construction industry beyond 2000. Nothing was excluded from the discussions and the subsequent report[1]. Many of the group's predictions came true—some in an alarmingly short time, whilst others have yet to materialise and probably never will. Among the lighter moments emerged the idea of buildings running themselves and deciding on the optimal environment for occupants. This was captured in the somewhat blunt headline: 'intelligent building attacks thick owner'. Thirty years on, it does not seem such a fanciful idea. In fact, years earlier Winston Churchill had famously observed that 'we shape our buildings and afterwards our buildings shape us'[2].

The common ground from Churchill's day, during which the world's first computer was invented, through the late 1980s with Berners-Lee's proposal for the world-wide web and on to the present day with cloud technology, is the exponential growth in processing power and data. Even so, power and data can go only so far; but introduce AI and there you have the catalyst for a major step-change – truly disruptive technology. Gone are the limitations imposed by traditional data-processing applications; in their place are predictive analytics and other advanced methods for extracting meaning and value from data. The point in all this reflection is that there is a history of events that has brought us to the present: it is not a recent phenomenon and has its roots well into the last century.

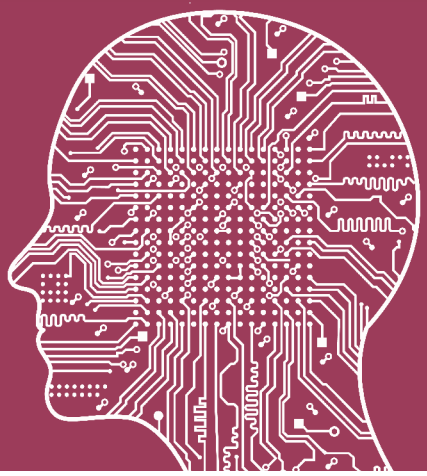
When we talk about AI, we should bear in mind that it is a branch of computer science. It is dedicated to the study of computer software capable of making intelligent decisions, reasoning and problem solving – no more, no less. AI, like human intelligence, needs to reside somewhere; in most cases, this is a device that we might use daily, such as a smart phone, or a machine endowed with cognitive capabilities to undertake a defined set of routines in a controlled environment. Despite these modest capabilities, AI has taken on the persona of a living thing, yet is wholly inanimate and impossible to touch. Its reputation precedes it, but with limited facts to back up the fiction that has been spun around it. Worse, hyperbole has given way to hype as corporations, start-ups and gurus, some of which are mentioned below, seek ways to exploit the brave new world they believe AI will create for them and the rest of us. Predictions are easy and therefore commonplace, but putting timescales to them is harder. To find the answers requires more probing and understanding of what has been achieved so far, what is currently under development and what is coming. For these answers, we need to be objective and rational, just like the technology that AI is co-creating.

Machine intelligence vs. human intelligence

Intelligence is an ability to reason, solve problems and learn. It integrates cognitive functions such as perception, attention, memory, language and planning. There are considerable differences in how individuals approach problems, apply reasoning and learn from their experiences – both successes and failures. As individuals, we can cope with a vast range of challenging situations, including those for which we have no prior experience, because we are capable of learning and doing so quickly. Our success stems from our innate ability to integrate how we perceive the environment, memorise features and information, respond to stimuli, make sense of it all and then communicate with others.

Understanding complex brain structures falls outside the scope of this paper, but breakthroughs hold promise for psychologists and computer scientists alike. Using a machine to mimic human traits is a slow process but has come a long way since the beginning of the machine age. The pace of change is set to quicken. Already, machine intelligence does, to a limited extent, simulate human intelligence; yet the deep cognitive processes that humans possess are nowhere to be found in any man-made form just now.

Humans do, of course, have more to offer than artificial general intelligence (AGI). We have emotions and can empathise with others. We can also decide to take up contrary positions. Our ability to make irrational or perverse decisions is a weakness, but that is what also makes us human and strong. Defining what machines can do and not do when endowed with AGI is where we must focus. Essential ground rules are needed now – see later box on *AI and ethics* (chapter 8.0).



3.0 Where is AI now?

Searching for answers is relatively easy nowadays, even if it can sometimes prove frustrating. In the past, we had to know that something existed before we could fetch it. Now, we can find even the most obscure information in moments. Emails and documents can be scanned at our command to find what we are looking for, what we might have forgotten and what someone thought we should know. AI has made that possible.

Whether we are conscious of it or not, most of us are carrying around the means to access a digital universe in our pockets or bags. It is limited now, but think back five years and what was possible then compared with the present, then go forward five years and another five. At some point, AI-enhanced technology will have gone way beyond what we need, so what is next? This is the conundrum we face.

Almost all of what is possible with AI either as software agents or embedded in devices and machines can be found in the public domain. Closely-guarded military secrets apart, the science is known, increasingly codified and available in published form. The literature on AI is expansive and bound in volumes of scientific papers published globally in peer-reviewed academic journals. Algorithms for this, that and the other application compete for space and, unknowingly perhaps, the attention of investors in the high-tech world. Contrast this with the headlines from the scientific and business press – *'A robot stole my job'*[3], *'The rise of the machines'*[4], *'March of the machines'*[5] and *'Humans need not apply'*[6] – and from publications closer to home – *'More than science fiction'*[7], *'Transforming the built environment'*[8] and *'Robots are coming, look busy'*[9] – where the messages are very direct or even discomforting as in *'Automation and anxiety'*[10].

AI has graduated from a purely academic discipline to a cluster of mainstream technologies that are increasingly impacting our lives. A recent report by Stanford University in the US[11] foresees substantial potential for the use of AI applications, including self-driving cars, healthcare diagnostics and targeted treatment, and physical assistance for care of the elderly. More interesting is that the report posits that AI's various applications and impacts would not occur independently of one another. This in turn is fuelling concerns about a point when a critical mass of technologies – all AI-enabled – might make connections that would threaten mankind. For now, AI is at least being focused in specific areas, although it cannot be long before connections between complementary applications occur – so-called synergistic benefits.

The Stanford report[11] cites computer vision and AI planning as prime examples of technologies enabled by AI. Here, the virtual world of video games has grown from simple graphics to become far bigger than even the film industry. Games have become serious business.

Another technology strand is deep learning, where a form of machine learning based on neural networks has made speech recognition a reality on our phones and other devices (e.g. Apple's Siri and Microsoft's Cortana), as well as around the home (e.g. Amazon's Alexa). Furthermore, its algorithms can be applied to other applications that rely on pattern recognition. Natural Language Processing together with knowledge representation and reasoning have dramatically improved web searches—even if we still feel we are faced with far too many choices to scroll through. Bear in mind too that the amount of information – big data – is growing at a phenomenal rate.

So far, these technologies are geared to specific tasks and it will be some time before we see an AI-enabled or intelligent machine taking on all-comers; but it will happen. It is mostly a matter of when. Smart money should be on convergent technologies, but the attraction of a single, potentially-disruptive technology can prove irresistible to some investors. Safer targets are cloud computing for big data and smart applications that can supplement and then replace legacy systems.

4.0 What effect will AI have on the socio-economic landscape?

AI is expected to have a significant disruptive impact on employment in general and particularly law enforcement and healthcare[12], raising concerns among politicians, regulators and within society about how technology companies should respond. This has led to the establishment of the Partnership on AI 'to study and formulate best practices on AI technologies, to advance the public's understanding of AI, and to serve as an open platform for discussion and engagement about AI and its influences on people and society'[13]. Its mission is to determine how society can harness intelligent machines for its benefit whilst keeping a tight grip on its risks. The partnership boasts IBM, Google and Microsoft among its membership.

Predictions about AI's impact on society, the economy and almost everything else that matters have received comment. Separating fact from opinion is not easy, with statistics used to argue contrary positions and, occasionally, the same ones. A survey conducted by the British Science Association (BSA)[14] to understand what the public thought about robotics and AI and how it would affect society and culture found that one in three believed that the risk of AI was a threat to humanity. 60% thought that the use of robots or programs equipped with AI would lead to fewer jobs within ten years. 36% believed that the development of AI poses a threat to the long-term survival of humanity. Many of the 2,000 plus responses expressed concern about the short-term effects of AI, with almost two thirds believing that it would lead to fewer jobs within 10 years.

In the BSA survey, there was a striking contrast between public perceptions of the role that intelligent machines should be allowed to perform. Roughly half would not trust robots in roles that included surgical procedures (53%), driving buses (49%) or flying commercial aircraft (62%). In contrast, machines could be trusted to carry out household tasks such as cooking and cleaning for older people or disabled people (49%), flying unmanned search and rescue (48%) or unmanned military (45%) aircraft, or monitoring crops (70%). It seems that the public is inclined to shun anything that is too close for comfort, but would be ambivalent to anything that did not affect it directly or which was regarded as one step removed.

A major question for governments and public policy makers is how AI could impact communities. For a view on this aspect, we can turn again to the Stanford report[11] which was tasked with considering the likely influences of AI in a typical North American city by the year 2030. Its panel of experts focused on eight areas: transportation, service robots, healthcare, education, low-resource communities, public safety and security, employment and workplace, and entertainment. The experts were asked to look back 15 years to reflect on progress to date and then cast their minds forward 15 years to consider likely developments.

They found that each area was characterised by different AI influences and challenges; for example, creating safe and reliable hardware (transportation and service robots), smoothly interacting with human experts (healthcare and education), gaining public trust (low-resource communities and public safety and security), overcoming fears of marginalising humans (employment and workplace), and the social and societal risk of diminishing interpersonal interactions (entertainment) [ibid].

Many of the developments that were considered by the Stanford experts were regarded as disruptive in terms of how the human workforce would be augmented or replaced by AI, creating further challenges for society and the economy that would require a holistic response. The experts argued that the design of AI applications and policy decisions made in the short-term were likely to have long-lasting impacts.

While the report concluded that there was no immediate threat to mankind from the current advances in AI, it did urge a wide range of stakeholders – researchers, developers, social scientists and policy makers – to ensure that AI's social and economic benefits were shared across society. It called for regulators to strengthen accountability, transparency and professionalism, rather than narrow compliance [ibid]. There is a role here too for bodies other than governments to ensure that a responsible approach is taken by their members towards their clients and the wider society. The Partnership on AI is one such response.

Quite what role governments should be playing is currently the subject of growing debate. Displaced workers might not be able to retrain for new jobs as easily as in the past, assuming it was possible then. Next time, there might be simply no jobs or too few to go around. This creates a burden for welfare systems that either must pay people not to work or find them something else to do; unfortunately, there is not much difference between the two. Already, countries in the Nordic region – Denmark, Sweden and Finland – and Germany are discussing how to deal with the situation when it arises, not if it happens. Paying everyone a basic income is one option, but there must be alternatives if an acceptable pathway to the future is to be found.

5.0 What effect will AI have on business in general?

In using historical precedent, it is often argued that new technology creates more jobs than it displaces. For example, banking staff have been replaced with ATMs yet we still find staff in banks to assist us; the same is true of retailing where more jobs have been created in e-commerce than have been lost in shops. Even so, those of us old enough to remember the typing pool and salary/wages office will know what technology has done to the office landscape. There are other parallels, including facility management, where helpdesks were once a physical location staffed by someone for fixed hours, with a telephone, pen and paper. The whole concept of helpdesks has been transformed by technology, with increasing levels of AI, providing support for customers and others across a diverse range of applications and sectors including IT, education and healthcare.

In the surveying field, quantity surveyors used to take off quantities manually from printed drawings and then have their bills of quantities typed by hand. The advent of computer-generated bills of quantities was initially frowned upon because bills were regarded as almost a work of art, while the quality of the end-product lacked the human touch. The more important issue, sometimes overlooked, was that bills were a means to an end and not an end in themselves. Thankfully, attitudes have changed and a surveyor's office today is as modern as the next and equipped with technical solutions supported by enterprise systems to enable it to compete in the business world.

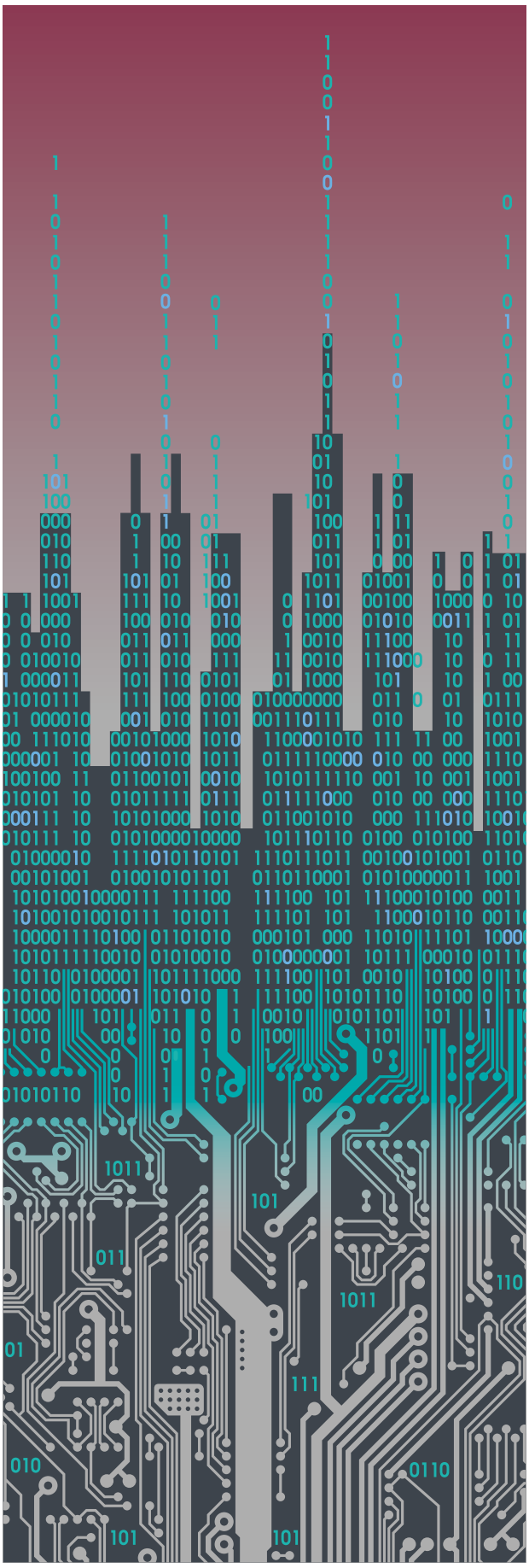
One feature of a world endowed with AI compared with the one before it is that change is now happening at an accelerating rate and capable of side-lining anything and anyone who is not essential to reach the desired goal. Technological innovation and diffusion is so fast that we risk losing work and businesses before we know it. The business process reengineering upheaval in the early 1990s was traumatic for Western industry as it realised it had lost entire markets to leaner, more agile competitors from Japan and East Asia in general. That is likely to be nothing compared to the next wave of restructuring and refocusing that AI will hasten.

The difference between then and now is that corporations restructured, downsized and became much more focused on quality, the customer and price; but they did so with the resources they had, mostly labour. Many survived, but some household names faded away and have gone forever. Those that did survive committed to major investment that over time saw factory floors transformed from work designed around skilled and semi-skilled labour to clusters of automation systems and robots, with relatively few workers in attendance.

The situation today and increasingly likely in the coming years is quite different to the revolution of the 1990s in manufacturing. Back then, it was mostly human capital; in the future, it will be fixed capital (i.e. intelligent machines). Manufacturers today cannot compete unless they have the machinery and tools, as well as highly-trained workers, for the job. As the stakes are continually raised, more capability and capacity will be required and that is likely to come from intelligent machines overseen by fewer workers, where the engineer has given way to the technician.

There are opposing or contradictory views when it comes to AI's effect on business in general. According to *The Economist*[5], as much as 47% of American jobs face potential automation in the next decade or two; whilst other studies estimate that less than 10% will go. There is a big difference. So, who is right? Is anyone fully in charge of the facts? Probably not. We can argue about the statistics and decide which of them we are prepared to accept and which we can choose to ignore. What cannot be ignored is the constant erosion of work that was once the preserve of trained managers and professionals. For instance, legal and accountancy firms are using increasing levels of technology to deal with routine tasks and those otherwise undertaken by juniors[15]. Credit checking, document analysis and searches in general can sometimes take hours to complete even with IT support. AI can be used to analyse far more documents in a fraction of the time and does not suffer from fatigue, stress or boredom. A study by Deloitte[16] has suggested that some 114,000 jobs in the UK legal sector could be automated within 20 years.

The real danger for the professions—and that includes everyone associated with the built environment—is to believe that clients are reluctant to accept work knowing it has been performed by a machine, always preferring the human touch. The truth might surprise, where cost, or rather the fee being charged, can be very persuasive.



6.0 What effect will AI have on the construction and related sectors?

Creating and sustaining the built environment brings together several industrial sectors that draw on diverse disciplines and specialisms which are formed into teams, often for unique projects. The fragmented nature of the industrial base of the built environment is frequently bemoaned, yet it offers opportunities for firms and, within certain limits, a wide choice for clients who can pick the best team for their projects. Traditionally, investment in fixed capital was greatest for those involved in physical construction work and less so for those whose role was providing consultancy services of one kind or another. In the past, firms needed high turnover and relatively full order books to make the investment and then they were subjected to downturns, as well as upswings, that left them wondering why they had bothered to invest in the first place.

A case in point is the use of 3D computer-aided design (CAD) and information modelling, which most of us would understandably regard as technology of the present. Yet, it has a history and a chequered one at that – see the box on *A short history of building information modelling* on the next page.

Interest in CAD and information modelling has moved up a few notches with more than a little help from AI, which has already found its way into design and other key application areas like portfolio management and project management. IT corporations such as IBM have released applications aimed at augmenting managers' decision-making capabilities whilst increasing interoperability (i.e. data exchange) and the overall effectiveness of enterprise systems. There are other examples in design, where mandatory codes provide the rules by which applications can be developed and integrated into existing design tools. Basically, the technology is there if you want to use it and know how to integrate it into the core business.

A short history of building information modelling

Working examples of commercial 3D computer-aided design (CAD) and modelling systems in the built environment were first seen in the 1980s, but the hardware was a major limiting factor since it was based on expensive, slow minicomputers (and mainframes before them). The creators of these systems, whose early work was born on the back of large-scale public-sector construction projects, were committed to modelling both graphical and non-graphical data for which powerful computing was essential.

Many of the algorithms at the heart of the software had been developed much earlier – they just needed sufficient hardware to make them happen. Features such as clash detection and interference checking were possible, and construction activity sequences could be rehearsed to optimise construction methods. Unfortunately, boom and bust cycles, which had long characterised the built environment, dealt a near-fatal blow to 3D modelling; simply, the economics no longer stacked up. To survive, vendors had to strip down their products to 2D drafting tools, where productivity gains could be more easily demonstrated.

In the 1990s, the pendulum began to swing the other way with relatively low-cost desktop computing rekindling interest in CAD; however, the earlier 3D software was now largely obsolete and so could not be easily ported to these new platforms. At the same time, the more aggressive vendors of 2D drafting tools saw a huge potential market based on the now ubiquitous PC and Microsoft's operating environment. This ground was captured at the expense of the weaker vendors and those behind the relatively few 3D systems that ran on platforms such as the Apple Mac.

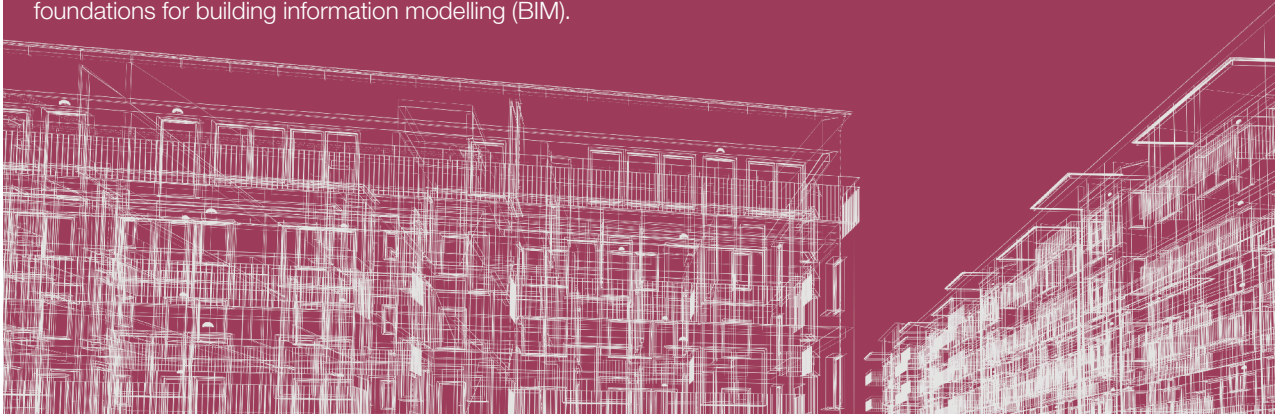
Meanwhile, data exchange between different systems, based on common standards, started to take hold, enabling collaboration within and between projects and delivery teams. International standards for product modelling were promoted, such as PDES, which subsequently gave way to STEP and, in turn, IFC – the foundations for building information modelling (BIM).

Despite the obvious emphasis on standards covering graphical and non-graphical data exchange, most of it was limited to graphics, with little non-graphical data. Much of the blame could again be placed on the economics, because of the effort needed to capture significant quantities of non-graphical data in a model before any benefits could be realised. Comprehensive classification systems could have provided a boost but required cross-industry agreement, which was slow in coming.

The 2000s saw the continuing growth of processing power, higher resolution graphics and automated design and detailing, leading to the gradual establishment of greater equity for practitioners who were now offered real choices at affordable prices as far as both hardware and software were concerned. It might not have seemed so then and even now; however, the cost of technology has shrunk in real terms over the years. This has led to greater interest in BIM, which has benefited from the advances made in gaming technology and the highly-competitive global market for games. Both have helped to drive down costs.

A weakness remains, however, and that is how to manage information and data exchange between organisations, within teams and across technical interfaces. Technology is in place, but the people and the processes with which they work lag some way behind. In other words, our ability to manage information and data in the digital world still has some way to go before it can be regarded as routine in the built environment. Recognition and support for BIM and standards are to be found at the national level (i.e. BSI), international level (i.e. ISO) and within the UK government that, to its credit, has continued to actively promote BIM for many years. All of this is good news for those with an interest in the next phase of development.

Taking meaning from our data provides us with information that has a value beyond the immediacy of the current task and supporting technical processes. BIM is becoming an enabler for AI in the built environment, because it creates the kind of working environment and IT infrastructure that benefits from applications where AI can excel.



6.1 Design and construction

Automation in design and construction is a longstanding theme, with design largely represented by BIM – see the box on *A short history of building information modelling* – and construction represented by semi-autonomous plant and equipment.

It should be clear though that BIM is not a recent innovation, neither is it disruptive. As our short history hopefully implies, newcomers to BIM would do well to appreciate the past before making claims about what it can do and how it will transform the industry. If anything, BIM is an enabler of innovation as it lays the foundation for a digital world in which AI can enhance current capabilities in design, construction, real estate and facility management. AI will help to redefine and extend the role of BIM; for example, identifying missing components and/or details, and forewarning of conditions that have been previously identified as unsafe, potentially inoperable or judged to be undesirable against defined criteria.

BIM will become the norm for new buildings and many other facilities, including infrastructure: it is largely a matter of time. A significant challenge remains, however, in applying BIM to existing facilities[17] [18], where the costs of creating a digital model might not be recouped for many years.

This is an area where AI can assist by analysing the evidence available in the physical and paper-based worlds. Pattern recognition is just one of several technologies which, if harnessed in affordable, semi-autonomous devices, could be used to map existing facilities and do so without much human intervention. You do not need to survey the interior of a building by hand if you have a device that can be programmed to scan it in detail and embellish the resultant model with UHD images and non-graphical attributes. Archaeologists have not been slow to see the potential and to demonstrate its power in recreating lost cities and subterranean worlds as digital models.

The first steady wave of construction automation was in the 1980s and was based largely on bolt-on enhancements that gave operators of mechanical plant and equipment more effective control over their machines through laser-guidance and ultrasound. In the case of earthworks, this quickly became a requirement for contractors who otherwise could not achieve the productivity needed to compete in the market. A second wave – this time exploiting GPS and mobile internet technology – would have brought various improvements to a construction site near you in the early 2000s. This development is continuing apace and moving towards the merging of features from the physical and virtual worlds so that the true status of the project can be shown at any time. There are clear benefits in health, safety and security, where potential hazards or risk events can be modelled in advance of construction taking place to design out danger and uncertainty.

The third wave, which emerged around the beginning of this decade, brings not only AI but also the internet of things (IoT), allowing connectivity via APIs (application programming interfaces) to a new world of services including analytics. These are mostly process-related innovations that will tend to diffuse slowly over the short term, gaining pace over the medium to long term as further levels of functionality are added.

Industry products have not been immune to the push of innovation. The most notable and visible example being building services engineering, where building automation and energy management systems have become the norm for high-end office buildings and similar facilities. Reduced operational expenditure – especially from lower energy bills – and a better quality internal environment make these systems a must-have for many clients, operators and occupants. The increasing use of sensors to monitor a range of environmental conditions is evidence of this technological push; however, it needs to have a purpose beyond mere data gathering. AI can help of course, but only if there is a plan for delivering benefits.

Even systems that have not changed fundamentally in decades are benefiting from innovative technology and AI. The design and installation of a modern lift/elevator is not so different from the manufacture of aircraft engines in that safety and efficiency in operation are primary concerns and goals.

Kone[19] offers what it calls 24/7 connected services, which use AI applications for remote monitoring and servicing. Equipment in its lifts/elevators gathers information from the installation's parameters, usage statistics and faults, which it sends in real-time to a cloud service where analytics are performed. Depending on the criticality of issues raised, a technician can be alerted to act immediately or specific maintenance can be scheduled. AI is expected to lead quickly to more advanced applications for Kone and its clients via APIs. Kone aims to connect over one million lifts/elevators and escalators to the cloud over the next few years. Recognising the importance of AI-enabled systems has allowed Kone to reposition itself as a company that manages people flows in buildings and other facilities on a global basis – a far cry from its origin as a machine repair shop in Helsinki.

6.2 Real estate and smart cities

Advances in automation, particularly those resulting from developments in AI, machine learning and IoT – the so-called 'Fourth Industrial Revolution'[20] – will be seen throughout the real estate sector. Technology is already impacting how cities are managed, how they develop and the kinds of talent and organisations they attract. Smart solutions to infrastructure challenges will help to differentiate cities. Intelligent machines will match or outperform human performance across a range of facility and estate-related activities, including those that require cognitive capabilities. McKinsey[21] predicts that AI offers a 40% automation potential in real estate, which is in the same region as that reported by PwC[22]. This figure covers all grades.

AI is driving smart, efficient buildings from design through construction and commissioning into operation and use. These buildings offer real-time control for occupants over the internal environment, which adapt according to various climatic and occupant factors. Successful smart buildings should add value by improving comfort through adjustments to personal preferences and, in this way, provide a direct, positive impact on individual productivity and well-being. For long enough, we have known what affects individual performance negatively; now, there is the chance to understand how to move in the opposite direction and enhance occupant well-being.

An emerging theme is how autonomous and driverless vehicles will affect new real estate developments. Providing sufficient parking for tenants in residential or commercial projects is paramount – a high parking ratio remains a major selling point for tenants leasing office space. Catering for driverless vehicles is the next step. There is also the effect of the gig economy on real estate, which is predicted to be worth £2 billion in the UK by 2020[23], and the way in which cities develop. Many younger, gig economy workers prefer to be in urban areas, which means that cities must be smart, connected and offer the most up-to-date technology. So, real estate becomes pivotal in attracting the best people.

On the corporate front, demand for digital talent will increasingly drive location strategies. Highly-serviced hubs will replace office acreage to support mobile knowledge workers when they need to interact physically with their co-workers and managers[24]. The fundamental nature of work as a location-dependent activity has already begun to change. Technology in its many forms will simply accelerate the pace of change. Many factors will alter the way we think about corporate real estate, perhaps the most notable being the move from asset provision to service provision[25].

These changes are already disrupting workers' lives on many levels and the consequent attitudes will, in turn, help to transform the workplace. A key aspect is disintermediation, where consumers are supported by technology to the extent that they no longer need agents in the traditional sense and, instead, can go directly to clients, shortening the distance and time between initiating an enquiry and obtaining an appropriate response. Tomorrow's agents will not be people, but smart apps.

As if these developments were not enough to suggest the demise of agents, there is the view from the World Economic Forum[26] that 'the real estate [sector] as we know it will disappear… Recent research indicates that it is not just brokers but the entire real estate [sector] that has to rethink how new technologies as well as shifts in demographics and behaviour will impact upon real estate jobs, skills and business models.' Hyper-connectivity is one core example. Whilst location remains important, the relationship and interdependence between physical and virtual spaces has changed dramatically because of improved mobility.

Five key factors are considered to influence how quickly and deeply hyper-connectivity is adopted [ibid]:

- technical feasibility
- the cost of developing and deploying solutions
- labour market dynamics
- economic benefits
- regulatory and social acceptance.

Another key factor is new or modified consumer behaviour. The sharing economy, where people rent or borrow goods rather than buying or owning them, has been predicted to generate global revenues of US$335 billion by 2025[27]. This could have a profound impact on existing sales channels and distribution networks.

6.3 Facility management

By its very nature as a provider of outsourced services, the facility management sector is extremely labour intensive. The workforce in the main carries out repetitive tasks to ensure the smooth operation of all kinds of facilities across all sectors of industry, commerce and social care. It is highly probable that within the built environment, the impact of AI will be felt the greatest in facility management. There are many ways in which facility-related services are likely to be affected. Some of these exist and are outlined in Table 1.

Most of the above is hardware related, with an increasing number of service providers – for example Mitie and Interserve – field testing and deploying drones for inspections utilising UHD and thermal-imaging cameras.

Software has an equally-important role too. Smart apps will coordinate the above tasks by analysing data in real time and taking responsibility for mobilising the hardware as appropriate to the tasks in hand. These smart apps will search and match information, compare problems with solutions and explain their reasoning before recommending a decision. Moreover, smart apps can learn and, in time, out-perform a human because they will have acquired more knowledge.

Example apps include determining the optimal strategy for managing facilities, maintenance regimes and manpower deployment. Users will put their questions in plain language and receive a response in a similar way. In fact, IBM Watson IoT[28] already offers a workplace management solution that combines data from sensors and equipment with powerful analytics to optimise several functions with facility management, including space management and energy management. Additionally, IBM Tririga® Facilities Manager[29] can be used to identify under-utilised space that can either be released to realise cost savings or put to more productive use. ISS – an international facility management firm – has already embarked on its own developments in AI supported by IBM Watson. It is likely that there will be more adopters if ISS can demonstrate clear benefits.

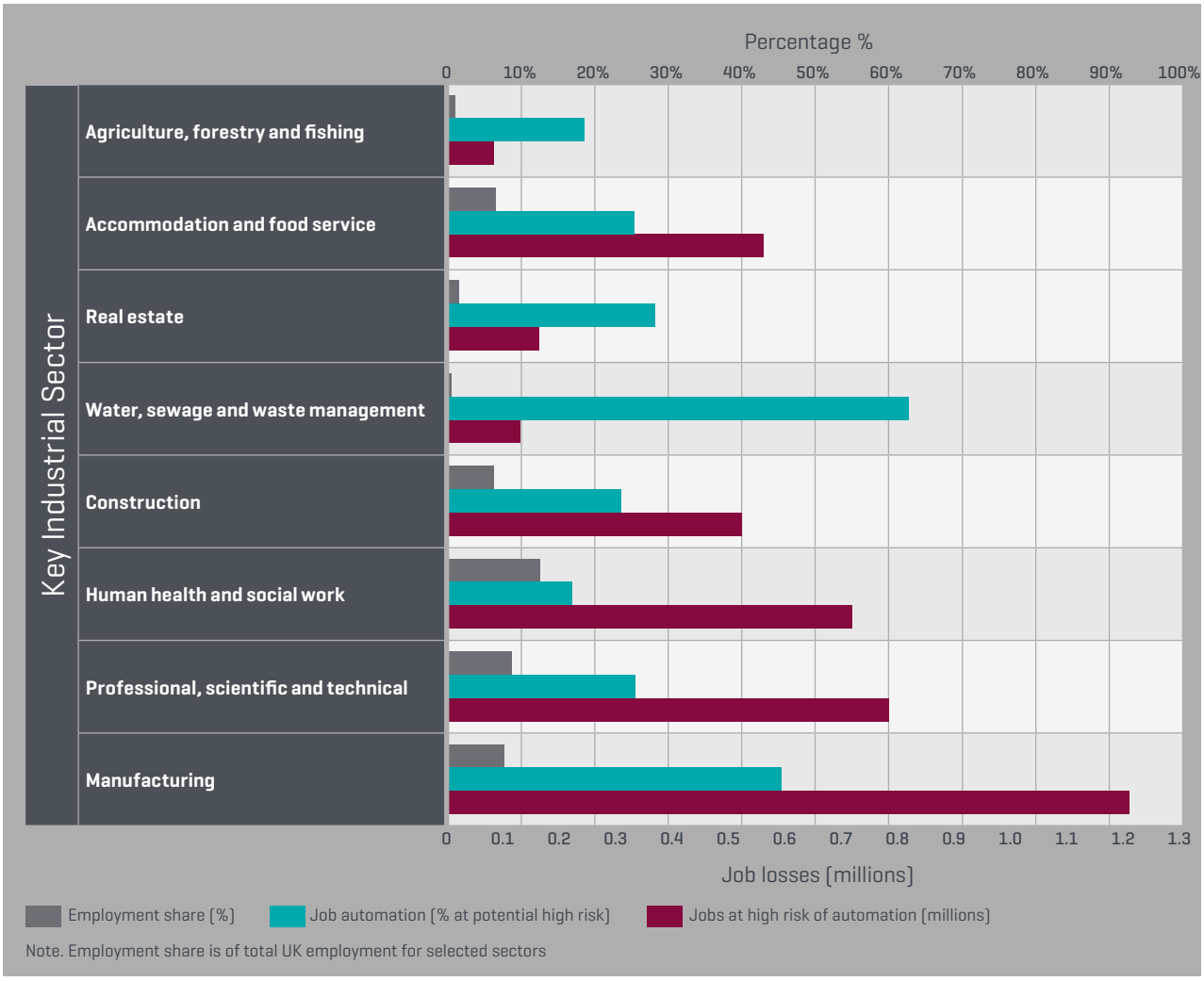
Table 1: Typical service areas in facility management and their AI solutions

Service area	AI-enabled solution and roles
Catering	Robotic chefs prepare food in the kitchens and autonomous guided vehicles (AGVs) and actroids serve it; later, they clear utensils and waste.
Cleaning	AGVs are used for internal and some external cleaning of surfaces. Actroids supersede them for certain tasks. Unmanned aerial vehicles (drones) are used for cleaning building facades.
Security/ inspection	AGVs and drones with UHD and thermal-imaging cameras increase the efficiency of security services and inspection regimes, whilst reducing risks to personnel.
Maintenance	Mechanical and electrical services maintenance is planned and organised by smart apps and carried out by drones, AGVs and robots. Parts are 3D printed in situ. Fabric maintenance is planned and organised by smart apps and executed by drones, robots and, later, actroids.
Reception/ helpdesk	Actroids perform reception and helpdesk duties supported by smart apps and data analytics. Remote monitoring and feedback are assisted by smart apps.
Logistics (deliveries and waste disposal)	Actroids oversee deliveries by driverless vehicles and coordinate porterage duties using AGVs. Smart collection points improve removal and recycling of waste.

The implementation of AI in all its modes will have a profound impact on the physical structure and organisational culture of the facility management sector, where large-scale job losses are considered likely in common with other sectors[22] – see figure 1. The lack of investment capital available to service providers also leaves them open to acquisition from firms in the technology sector, especially those providing AI-enabled hardware and software.

Lack of knowhow and investment capital on the part of incumbent service providers is likely to mean that their workload becomes progressively smaller and smaller over time. The business strategies of service providers and their clients, in terms of how they treat AI, will be crucial in determining how both they and the facility management sector evolves. The time to act is now, not when the point of no return is reached, which is when AI has created a critical mass of commercially-available intelligent machines and smart apps.

Figure 1: Potential job losses in key industrial sectors



Source: (Redrawn from PwC (2017), UK Economic Outlook, March, London: PricewaterhouseCoopers, p. 35) [22]

7.0 What effect will all of this have on business strategies?

Employers have moral and commercial obligations to ensure they do not become victims of AI or, indeed, succumb to any other foreseeable event from a lack of attention. Instead, they should seek out and maximise the opportunities while minimising the threats. Employees, investors and other stakeholders have a reasonable right to expect that informed decisions are based on objective analysis of arguments from different sides. Even if the decision is to do nothing, at least for the time being, let that be a decision that has arisen from active consideration of the matter and not some knee-jerk reaction for want of information or time. The landscape of industry and commerce in the last century is littered with examples of firms that decided something was not going to impact them; or they could somehow react once everything became that much clearer.

The simple message is that organisations need to act ahead of events and monitor developments if they are to have a realistic chance of controlling their business strategy, direction and financial health. Obviously, resources cannot be put into controlling something that is beyond the organisation's control; but resources can be used to understand the most appropriate responses under different conditions and scenarios. The very nature of AI is such that it can impact in so many ways: it can affect customers, suppliers and investors, as well as one's own activities and business processes. The drivers affecting the business, for example the need to reduce operational costs and to find new business opportunities, must be understood too so that the applicability of AI-based solutions can determined.

On the highest level, the aim should be to ensure there is a policy or strategy to deal with the impact of AI and any other potentially disruptive technology, where that strategy is aligned with the business objectives. The facility management strategy should already be aligned with the business strategy[30], given that space of some kind is going to be required into the future and that the delivery of facility-related services is probably labour intensive, and possibly expensive, at present. The business strategy, facility management strategy and strategy for AI should be aligned within the organisation. All three must be considered as interdependent; they cannot be uncoupled or disconnected.

Typical questions for senior management should centre on whether there are any business drivers that would call for a reduction of headcount in any areas or the need for higher levels of productivity and/or quality. Senior managers should address the question of whether the existing business strategy or any business development plans anticipate greater use of technology and if this would mean utilising disruptive or innovative technology to create or enter new markets, or to consolidate those existing. These are important questions that require serious consideration.

On the facility management side – where operational expenditure can be high for many organisations – there should be a clear understanding of the relationship between core and non-core business. In the latter case, facility-related services should be assessed in terms of their work content against the potential benefits and costs of deploying AI-based solutions, both hard and soft. The organisation should, however, be mindful of the possible effects resulting from any redrawing of the line between core and non-core business, not least where additional investment in fixed capital assets might be necessary. The implications for the delivery of facility-related services should be considered, including relationships between service providers that might be impacted by the introduction of AI in whatever form. There are also questions about liabilities – see below – and intellectual property which are best attended to before the event rather than struggling with them as an afterthought.

Further questions for senior management should therefore address the extent of core business processes that are currently supported by some form of AI-based solution and if there are any support services for the core business that utilise some form of AI. The extent to which AI-based solutions could be introduced in substitution of, or complementary to, existing service delivery should be examined. The answers might reveal that the once distinct dividing line between core and non-core business is now looking rather blurred. In some cases, it might be advantageous to integrate the supporting, non-core business into the core business, because there is no longer any point in trying to differentiate between the two. When non-core business is intertwined with the core business, attempts to distinguish between the two would appear to serve no useful purpose.

If a change in the division between core and non-core business is thought likely then it is important to consider the very nature of the relationship with service providers. Moreover, it would be important to consider the changes that might be required to contract terms in general and the apportionment of risk and liability. The risks – threats (downside) and opportunities (upside) – to which the organisation is exposed must be monitored continuously. Some threats will have an impact on operations and, therefore, the facility management response.

On the upside, there are opportunities that could be exploited for the organisation's benefit. Keeping on top of risk assessment is one area of business that is not always well handled. The use of AI-based solutions (e.g. smart apps and other embedded AI-based solutions) could enable the organisation to be more aware of the probability and impact of risk events, both negative (i.e. threat) and positive (i.e. opportunity). In this way, AI can be both a threat and an opportunity, though not in equal measure.

Facility owners, operators and service providers must consider the arrangements for systematically identifying, logging and assessing risk events. They should make use of previous experiences in responding to risk events and the extent to which technology is, and could be, used to support risk management. The firm's senior management should address a few fundamental questions; for example, have smart apps been considered for implementation as part of the organisation's enterprise system or perhaps as standalone solutions? Furthermore, is a change in the allocation of risk between the organisation and service providers envisaged as a direct result of the use of AI or other advanced technology solutions? Again, the question of liability comes to the fore as does the answer: to have a thoroughly-considered position and then to ensure that it feeds into the AI strategy, which in turn will flow smoothly into the business strategy.

Image sources: 1 OlegDoroshin / Shutterstock.com
2 Ned Snowman / Shutterstock.com 3 Graphical_Bank / Shutterstock.com

8.0 What professional and other services will be affected and how?

It should be clear that all services, including those that we have long regarded as the preserve of established professions, will be affected by AI, which will bring fundamental changes in the way that the expertise of specialists is available to the rest of society[31]. The level of impact will, however, depend upon the service and the timescale over which it is likely to occur. For example, our ability to learn from previous projects, performance in the delivery phase and the operational facility in use is going to be improved by a combination of AI and big data. Performance measurement, including benchmarking, is generally not well developed in practice. The degree of objectivity that is claimed is often open to question, because people tend to select what they prefer to see as the reality. AI removes the subjectivity and can present whatever can be deduced from the facts. It is then for the human decision maker to determine what action is necessary.

Having been clear that all services will be affected, then how does this manifest in the current roles as exercised in the design, construction, commissioning and operation and use phases of a new or refurbished facility? For an indication of the effects, we could reasonably speculate that investors, owners and owner-operators would wish to maintain their buildings at the cutting edge of technology. Designers have a role here in designing for automation, so moving beyond the now-accepted concept of design for construction, i.e. constructability, to future-proofing their designs. A modest increase in capital expenditure could be easily offset by savings in operational expenditure from the adoption of robotic cleaning, catering and security, remembering that these tasks are near-continuous operations throughout the life of the facility.

An intermediate step could be wearable technology and smart apps enhancing the capabilities of workers, although this could be regarded as a matter of putting off the inevitable. Either way, the ultimate end-users of services – occupants and visitors – might be adversely affected by the mere fact that the automated facility is soulless. The idea that a commercial office might be taken over piece by piece by automation and robotics to the point where there are no longer any human workers in the facility begs the question of why we should want to continue building as we do. For whose benefit would fully-automated commercial offices be designed, built and managed? The business processes that the offices contain could presumably be subsumed into some other arrangement if they are still required.

Expect substantial empty office space in the future, not all of which is going to be capable of conversion to other uses such as housing. When this happens, there could be wider implications from a lowering of the investment value of real estate and its effect on pension funds.

A far bigger area of interest and more immediate concern is the smart city. The complexity of a modern city and the pressure it places on resources of all kinds – human, natural and spatial – suggests that support from intelligent machines might prove beneficial. Since so much of the world's population lives in cities and others continue to gravitate towards them means that threats and opportunities will occur in ever-increasing concentrations.

The Stanford report[11] foresees AI in transportation and associated services, healthcare and education, public safety and security, employment and workplace, and entertainment. For our cities, these translate into the following:

- driverless vehicles (including trains, trams, taxis and cars)
- drone deliveries
- automated health-check facilities
- virtual campuses for learning and entertainment
- law enforcement actroids
- unmanned restaurants
- 24/7 surveillance.

The last of these would be an inevitable consequence of removing people from frontline positions whilst, at the same time, wanting to exercise control over events. Knowing everything about anything is not hard when technology is fully deployed. The only way to keep citizens safe is to protect them from themselves, or rather those in the population who might cause harm to others. Big data thus becomes Big Brother, heralding in the era of a dystopian society.

Clearly, there are many ethical and social issues to be addressed about the way in which intelligent machines can exist alongside us[32]. It is vital to address them now not once we have been forced to accept a different way of life. By that point, big business will have made sure that nothing is going to get in the way of its profits.

On a more sanguine level, AI could be used to support populations in more rural areas and help to encourage people to move away from cities, or at least hold their numbers at sustainable levels. When there is less need to rely on people to perform basic chores in places where there are so few people around, rural living supported by intelligent machines could help slow the flow of migration to urban areas.

Connecting people in rural and remote communities is a real concern for policy makers in healthcare, education and transportation. Maybe this is where AI could do much good in the long run. There are plenty of applications in agriculture and forestry – robotic planting, spraying and harvesting to name but three – that could make worthwhile contributions to society in general. It might also encourage a move away from intensive farming – a practice disliked by many – towards more humane methods of helping to feed the population.

In the above discussions, aside from the obvious concerns, there are many implied threats and opportunities for the existing workforce, including those relating to professional and managerial grades. It is hard to see what those displaced by intelligent machines might do; yet, there is some prospect of future gainful employment for those who are less subject to the pressures accentuated by cities, even smart cities. For instance, there might be opportunities for premature retirees from a return to more traditional ways of life which might perhaps see a modest upturn in cottage- and craft-based industries. This might not be everyone's preferred vision, but it would be better than the potential Orwellian future highlighted earlier.

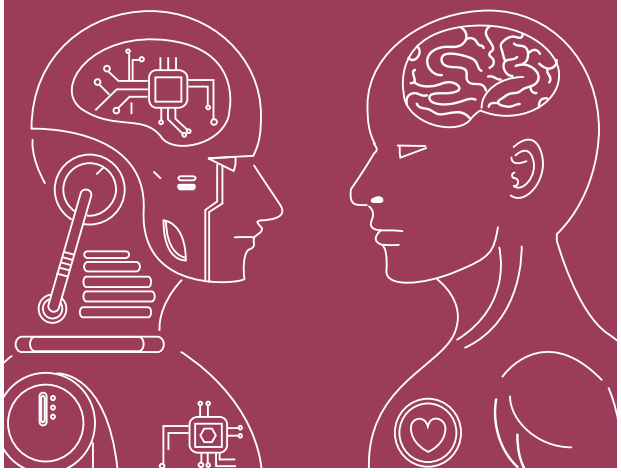
AI and ethics

AI has the potential to take over so many tasks, routines and day-to-day responsibilities; but just how far should we allow AI to go? Our earlier discussion on machine vs. human intelligence argued for effort to be put into establishing the boundaries for AI right now. There is an argument for laying a baseline for artificial general intelligence (AGI) that targets the kind of tasks humans routinely perform. This approach is being championed by an influential group of thinkers and entrepreneurs, backed by corporations developing AI-related products.

OpenAI[33] exists to build safe AGI and ensure that its benefits are distributed as widely and evenly as possible. By providing relatively easy access to tools for building smart apps and intelligent machines, it expects that first generation AGI will promote wider acceptance and understanding of how AI can be utilised. The mission of this not-for-profit research organisation is to provide the widest access to AI tools. Whether this will turn out to be a help or hindrance depends on whose perspective you adopt.

There are, regardless, concerns of an ethical nature that stand in the way of bringing AI to the masses. Inequality, unemployment, artificial stupidity, racism, security, safety and machine rights are topics of current debate. Specific questions about machines being able to acquire empathy and exercise moral judgment are deeply troubling for many people and understandable; moreover, such traits challenge the very meaning of humanity.

Our paper offers no answers to these or related questions, but it does try to raise awareness of a complex set of issues and possible dilemmas that stem from our collective pursuit and development of the products of human ingenuity.



9.0 Scenarios and timescales

Presently, creating and sustaining the built environment is heavily dependent on non-UK citizens for its labour[22]. Contracts awarded during the period of Brexit negotiations, and which run for several years, could leave construction firms without the labour they anticipated and vulnerable to failure. Multiple tiers of subcontracting might disappear with a return to more directly-employed labour – the UK government's attitude towards the self-employed is evidence of a major change here.

An end to cheaper labour in general would force construction firms to consider alternative means and construction methods, some of which are bound to involve greater degrees of off-site prefabrication and on-site mechanisation and automation. In the latter case, a difficulty will be one of how to make the investment in expensive fixed capital, i.e. automated plant and equipment. It is extremely unlikely that construction firms could afford the investment themselves, without the volume and continuity of work to justify it. Unless profit margins rise and, with them, the price of construction work, there is unlikely to be the financial stimulus for investment.

This problem will probably be solved in much the same way as at present through suppliers of operated and non-operated plant and equipment. US and German construction firms are claimed to have far greater utilisation of automation than their UK counterparts [ibid]. Curiously, the same source notes that Japan, whose construction industry has been using automation and robotics for two decades, is at almost the same level as the UK. China remains highly geared to cheap domestic labour, yet is the world's largest producer of automation and robotics. If the statistics are to be believed, at least in part, one possibility is that we could see a new wave of foreign direct investment especially from the US and China as new trade deals are concluded.

A likely consequence is that some of the UK's weaker firms would face takeover bids in much the same way that professional services firms experienced in the post-millennium era: it has happened before, when the EU single market became a reality. It is conceivable too that EU-based firms, notably those in Germany, might consider tie-ups and takeovers where they have prior experience of the UK market. Conditions look set for significant changes in the composition of the UK construction industry, the facility management sector and the ownership of firms.

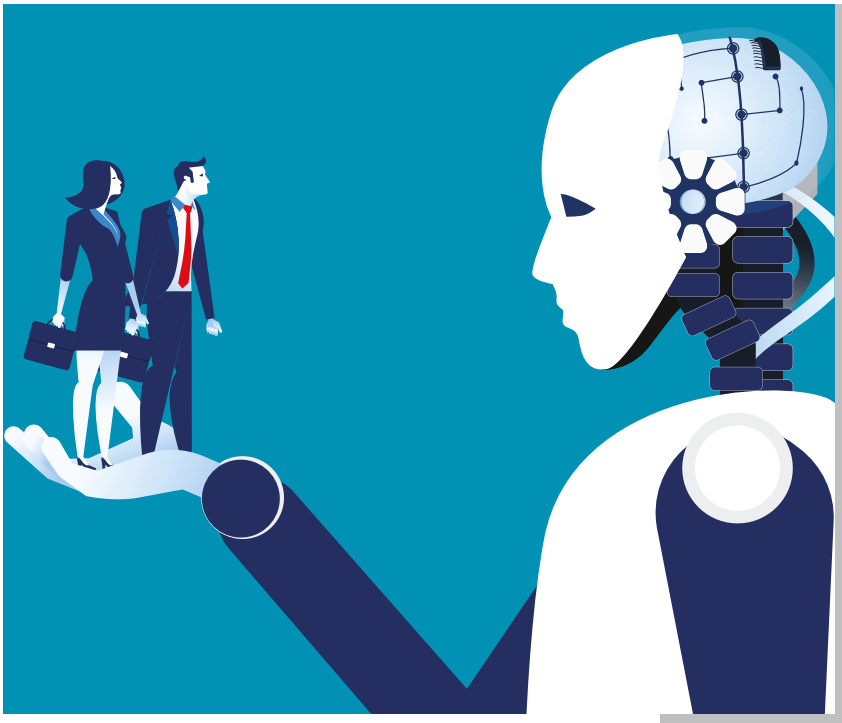
When will the facility management sector reach the tipping point where the impact of AI hits hard? It is difficult to say. The exponential development of both hardware and software will undoubtedly be a major contributory factor as far as timing goes. Other factors will be client and supply chain pressure. Once these factors are activated, the industry changes discussed earlier would likely materialise within three to five years.

AI in all its forms will come into its own by taking over jobs that are repetitive and where a machine could replicate the actions of a worker within reasonable limits. Making sure the built environment remains productive and sustainable requires that many tasks are coordinated and controlled. The main areas in which these tasks are performed are as follows:

- cleaning
- waste disposal
- security
- catering
- mechanical and electrical services maintenance
- reception and customer experience
- condition surveys and logistical support.

One scenario could be if all these tasks were taken over by some form of AI then the facility management sector would be affected by substantial job losses, which would also influence the social/economic landscape of the country. When manufacturing was automated, much of the displaced workforce transferred to the services sector. With the automation of the services sector there will be few places to go.

Another scenario concerns the sector's structure and working practices. Will the layers of outsourcing be depleted? Will the decision-making be transferred from real estate and facility management to technology? Decisions regarding the practices in the workplace could be transferred to the chief technology officer in client organisations. This would result in a radical transformation of the supply chain, allowing more companies from the technology sector to enter the facility management sector. We are likely to see mergers and acquisitions where one side tries to defend its market, whilst the other is trying to encroach upon it. Either would make financial sense from a client's perspective.



This brings us again to the matter of timescales. We do, however, need to clarify the parameters of the term tomorrow when considering a future world for those owning and occupying the built environment. The pace of change and the impact of quantum computing mean that the likely changes within three-to-five years will pale into insignificance compared to those of twenty years hence. With the exponential development of technology in other sectors, it would be reasonable to say that the development of AI will follow a similar pattern. If that is the case, the next five to ten years will be crucial for the implementation of AI in the built environment.

It should be noted that, historically, firms have been slow to adopt new technology. Currently, in the facilitiy management sector, there are drones and robotic floor cleaners, among others, which is hardly evidence of a take-up of innovative technology; in the case of AI, the position is likely to be much different. There will be pressure from clients and the technology supply chain to invest – not just hardware and software, but in getting the organisation and its people into shape to conduct this new line of business. This pressure is likely to result in a growing number of pilot schemes over the next three to five years.

Last major FM service provider taken over

March 7, 2032: London

GenFM PLC today announced that it had accepted an offer from Cynergist Intelligent Technologies, Inc. for the 51% of the company that it did not already own.

After weeks of speculation, the California-based manufacturer of autonomous workplace agents has succeeded in consolidating its position as the leader in the global facility management (FM) market by acquiring the business of the last major service provider. GenFM was the product of several mergers over the past decade in its struggle to hold on to a shrinking market for general FM. Wafer-thin margins – the result of fierce competitive bidding – left GenFM with little alternative but to accept the offer from Cynergist in the hope that it could retain some jobs, especially for its senior staff and key account managers, many of whom had been with the company for years.

Substantial redundancies in GenFM's blue-collar workforce are however inevitable as clients – some of them the UK's biggest facility owners and operators – continue to shun human resources and opt for autonomous agents with ever-increasing levels of intelligence. A recent decision by the UK government to progressively phase out low-skilled jobs in public healthcare facilities, prisons and educational establishments meant that the writing was on the wall for GenFM.

As the dominant service provider, GenFM had been under considerable pressure to raise productivity, eliminate errors and reduce operational expenditure. According to departing CEO, Mike Smith, 'we have simply been unable to match the challenges faced by our business as clients have demanded greater cost savings. The figures just don't add up. Reluctantly, we have decided to accept that maintaining a large workforce is no longer viable.'

The BBC's Technology Correspondent added that 'GenFM was the last behemoth of the FM sector and would be remembered for having tried to use its huge workforce to fend off the onslaught of autonomous agents whose cost had halved every two years whilst their capabilities had quadrupled'. Shares in the few remaining FM service providers plummeted on the news of the acquisition.

Time stands still for no one

Let us move our digital clock forward to 2027 and imagine that you are the Chief Technology Officer at a global bank, headquartered in London. Last year, you made 85% of your facility management team redundant. Today, AI plays a vital role in your business, handling much of the previous team's process-driven work through portals, apps and software as a service (SaaS). You have worked with the management team to oversee a significant reduction in headcount, and the personnel you now employ, across all departments, have been re-trained with technology-enhanced tools at their disposal to maximise productivity.

Co-working is now increasingly popular in your bank, and you have been restructured like a series of smaller firms. Your office is let out in the evenings and at weekends for use by commercial hubs and educational establishments. Catering, landscaping and front-of-house are significantly automated, with robotic cleaners, gardeners and chefs now accepted as the norm, but still working alongside an efficient team of multi-skilled analysts and managers. Your customers demand a level of service and centricity, which is impossible without access to the latest big data tools. Augmented reality now features in your meetings and in the much-reduced high street presence.

Now imagine waking up to the world in 2037. It is a world where almost every aspect of the life we know today is transformed, let alone in 2027. This scenario is, to quote world-renowned physicist, Stephen Hawking, either your wildest dream or a living nightmare, depending on your appreciation of technology, your acceptance of change and your ability to learn and adapt. We are now fully immersed in the automation age predicted years earlier by McKinsey[21].

Appropriately-dressed actroids, alongside holograms, are commonplace within office receptions and in the now more limited, but highly technical, retail stores that have been replaced by virtual reality. Jibo-style robots play a key role in our homes and 3D printing of many goods has become the norm, including many of the furnishings we need in apartments and small offices. Logistics has been transformed with drones delivering our orders from floating warehouses.

Green roof terraces and smart waste control make our cities, towns and the facilities within them much more appealing. Multiple surfaces have become power plants with integral renewable energy: gone are the dinosaurs of the early twenty-first century – fossil-fuelled power stations. The well-being of our workforce is paramount and it benefits from responsive furniture, which adapts to size, height, temperature and light. Our commercial buildings and, increasingly, our residential buildings are cognitive: as guests arrive, data in our calendar is accessed and the lift is sent down to greet them by name. These IoT cognitive devices now teach themselves, making your life increasingly easier and your own roles increasingly redundant.

Be prepared for change as the only constant in your business and personal life.

10.0 Summary of impacts and recommended actions

The time is ripe, even overdue, to take a cold, hard look at what a highly-disruptive technology could do to industry in general and facility management as the discipline and service sector that is responsible for maintaining and sustaining the built environment. It might come as little surprise to those who have some understanding of what AI can achieve that we are facing a genuine watershed.

As other sectors see increasing incursions into their routine work – some of it welcome, some of it feared – design, construction, real estate and facility management need to come to terms with the potential fall-out from a world in which intelligent machines can increasingly out-perform the human workforce. In the field of medicine, where there is a shortage of certain skills, robots are welcomed by surgeons to provide highly-repeatable performance under their watchful eye; elsewhere, workers are losing their jobs in droves because a machine has already mastered their skills. The prognosis for the future of employment is mostly negative. Unlike previous waves of change, there might be nowhere for a largely semi-skilled workforce to go, even if re-trained.

There are mixed messages coming from the deployment of ever-more sophisticated devices embodying increasing levels of intelligence. The scientific community and pundits alike offer contradictory advice on what AI will mean for us all and when. Deciding on who is right is an impossible task and is best avoided. This technology is bigger than anything that has come before, apart from the (first) industrial revolution. Instead, organisations of all kinds should take a close look at what they do now, what they want to do in the future and then assess their position and chance of survival against the backdrop of developments in AI and other advanced technology.

This should reveal the kind of changes that are necessary to have a future over which some control might be exercised. The organisation then needs a strategy to help it navigate through the coming few years that will see increasing clarity over the impacts that AI will have. It might not be possible to avoid them, but at least it is possible to plan for the inevitable and then attempt to find a way through it all. In this game changer, ignorance is the very worst of companions.

11.0 Conclusion

The views of many individuals and organisations have been considered in this paper, not all of which concur. Although the sources cited differ on the detailed level, they tend to share the same broad conclusion: AI will impact just about everything. The question is the extent and timescale involved. Our prognosis for the future has been laid out in the previous sections so there is little point in repeating it here. Even so, we feel we must underscore the need for surveyors of all disciplines as well as other built environment professionals to understand what it can do for their own work and life outside work, and to do so sooner rather than later.

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