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The Impact of Emerging Technologies on the Surveying Profession

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Report for Royal Institution of Chartered Surveyors

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Executive Summary

"Never until now did human invention devise such expedients for dispensing with the labour of the poor." Luddite pamphlet

Predictions that automation will make humans redundant have a long history, going back to the First Industrial Revolution, when textile workers, most famously the Luddites, protested that machines and steam engines would destroy their livelihoods.

The Fourth Industrial Revolution has started with billions of people connected by mobile devices, with unprecedented processing power, storage capacity, and access to information.

The opportunities that this situation presents will be magnified by emerging technologies such as artificial intelligence, robotics, new materials, energy storage, and quantum computing.

The idea that manual work can be carried out by machines is already familiar; now the Fourth Industrial Revolution sees machines performing tasks done by information workers too. This is likely to usher in a period of disruptive change for all industries including surveying.

Five key areas of technology are identified that will have a significant impact on surveying:

- The Internet of Things (IoT)
- 5G communications
- Machine learning & robotics
- Building data
- Distributed ledger technology.

Each of these is likely to be disruptive in its own way and in particular areas of the industry. In the assessment of impact, this paper takes as its starting point the structure of the surveying profession as defined by RICS, overlaid with the functional structure of the industry. This allows us to draw up a skills matrix for surveying functions.

Surveyors are multi-skilled professionals. Each job title will share a set of basic tasks and add to this a specialism. For example, brokers will share a set of common task descriptions covering reporting, monitoring of market information, etc. with other disciplines, but will focus on specialist expertise in sales or lettings.

In order to model the impacts of a digital future, this research uses the Remit process model as a guide to break down these functions into a set of 43 tasks.

Each task has then been scored according to its content in five areas:

- Data content
- Algorithmic content
- Learning content
- Interpersonal skills
- Physical presence.

Of these tasks 18 – nearly half – exhibit a high degree of vulnerability (70%-100%) to automation now and over the next decade. A further 20 show a significant degree of vulnerability (20%+) over the same period.

Surveying appears to be an industry in which 88% of the core tasks are ripe for automation to a greater or lesser degree. This finding acts as a harbinger for discontinuous and disruptive change. How aware are industry participants of this coming change?

In order to take soundings from the whole industry, an online survey was used to solicit opinion. 154 responses were received. The questions covered nine scenarios based upon the likely impact of technology in different areas:

- Data
- Valuation
- Risk evaluation
- Lease preparation
- Monitoring of market conditions
- Lease management
- Rent collection
- Service charge collection
- Acquisition and disposal of investment property.

Responses were solicited as to likelihood on a scale of zero (unlikely) to 100 (very likely). The overall mean across the survey was 46/100.

The most likely area for automation was felt to be collection of rent which scored 70/100. The least likely candidate for automation, at just over 28/100, was felt to be acquisition and disposal of property. The majority of other responses were clustered around the mean.

At a functional level the impact of automation is likely to be especially disruptive in the areas of lease management, valuation and property, and asset and facilities management and will be seen in different ways:

- An increase in the consistency, transparency and timeliness of transactions;
- A step change in the accuracy and timeliness of reporting;
- An explosion in the number of sensors deployed under the IoT umbrella will increase the visibility and responsiveness of all buildings and facilitate remote facilities management;
- A reduction in the cost of managing a portfolio of buildings, it being likely that the headcount in particular areas – valuation for example – will be reduced significantly; and
- A change in the skillset required. Surveyors are likely to become either data scientists or client managers. This has implications for real estate education going forward.

Longer term, this revolution paves the way for property to compete on a level playing field with other asset classes, becoming a wholly securitised, flexible, and dynamic asset underpinned by its residual value.

1.0 Introduction

This paper focuses upon how changes arising from emerging technologies will impact property professionals.

Two methods have been used to assess these impacts. Firstly a process model has been applied that breaks down a range of surveying roles down into distinct tasks, and, using this analysis for each role, calculates the likelihood of it being impacted. Secondly, a survey has been carried out eliciting the thoughts of property professionals on how, and to what extent, certain surveying tasks would be affected by new technology.

Together, these insights provide a fascinating viewpoint on how traditional surveying roles may change in the coming years.

1.1 The Fourth Industrial Revolution

We are standing on the brink of a technological revolution that will fundamentally alter the way in which we live, work, transact and relate to one another.

The First Industrial Revolution used water and steam to mechanise production. The second used electricity to create mass production. The third used information technology to automate production. Now a fourth is building on the third; a digital revolution characterised by a combination of technologies working together. The transformation being wrought is disruptive in its scale, scope, and complexity.

The Fourth Industrial Revolution has started with billions of people connected by mobile devices, with unprecedented processing power, storage capacity, and access to information.

The opportunities that this situation presents will be magnified by emerging technologies such as artificial intelligence (AI), robotics, new materials, energy storage, and quantum computing.

As with all disruptive change it also creates challenges. In the 21st century, global platforms like the internet and mobile communications can be subject to 19th century governance that, based on certain geographical and political boundaries, can raise barriers to innovation.

Traditional economic systems are breaking down under the strain of porous digital borders and the increasing openness of information has the potential to bring about fundamental geopolitical change. Concepts of 'Government' and 'Country' can be seen, in some ways, to be losing ground to a focus on the individual and the corporate.

Examples of artificial intelligence already abound, from self-driving cars and drones to virtual assistants and trading software. As computing power has increased – and the volume of data available with it – AI has made significant progress.

Digital manufacturing technologies, meanwhile, proceed apace. Engineers, designers, and architects are combining computational design, additive manufacturing, and materials engineering to pioneer a symbiosis between the products we consume and the buildings we inhabit.

During the end of the Third Industrial Revolution, the real estate industry saw significant impacts from the growth of technology. Offices saw the advent of genuine flexibility in workspace and, to a lesser extent, workplace. Industrial property witnessed the rise of the logistics warehouse – in many cases complete with automated handling systems. Retail has experienced competition from the growth of online merchandising in ways that have greatly surpassed the boundaries imagined twenty years ago.

Disruptive though these changes were for the industries concerned, as far as the property industry was concerned, the pace of change was measured. Change was evolutionary rather than revolutionary.

The Fourth Industrial Revolution is likely to change all that.

1.2 A digital future for real estate

A digital future in real estate and, in relation, the surveying industry will depend upon the intersection of policy and the economy in addition to cultural changes, as referenced elsewhere in the RICS Futures programme[1]. This paper focuses upon the rapid and often disruptive changes wrought by technological developments. As a service profession, change is inescapably reactive to stakeholder-led changes, particularly those of clients.

The pace of change in the technology sector is very fast indeed when compared to the scale traditionally seen in the built environment. Companies are growing to prominence very quickly (and sometimes disappear with even greater rapidity). Most mainstream digital services platforms are in their mid-teens and even companies like Apple and Microsoft are only around thirty years old. By comparison, British Land, one of the UKs leading property companies, celebrated its 160 year anniversary in 2016.

This relative pace of change applies at a product level as well. The Royal Exchange in the City of London dates to 1844 and was rebuilt on the site of two previous exchanges going back to 1566. This contrasts, for example, with a product lifecycle of between 9 and 18 months first identified by Burruss & Kuettner (2003) for Hewlett Packard printers.

1 See Cook, D and Chatterjee, P (2015) RICS Futures: Our Changing World (London: RICS) [ONLINE] Available at: http://www.rics.org/Global/2015_RICS_Futures_Our%20Changing%20World_76p%20(2).pdf [Accessed 21 April 2017]

Buildings have been heavily impacted by the advent of technology, from their location through to design and construction, to how they are used, managed and transacted. It is expected that new and changing technologies will continue to have a significant impact.

As technology transforms business models and processes, it is also changing the way employees work. McKinsey research (Chui et al, 2015) finds that already-proven technologies could automate as much as 45% of the tasks individuals are currently paid to perform.

Existing manifestations of technology like cloud computing and social media are expected to continue to reflect changing patterns of use over the next decade but there are five key areas of technology that will have a significant impact over this timeframe:

- The Internet of Things (IoT)
- 5G
- Machine learning & robotics
- Building data
- Distributed ledger technology.

The Internet of Things

The Internet of Things (IoT) is the network of physical objects – devices, vehicles, buildings, and other items into which electronics, software, sensors, and network connectivity have been embedded – that enables these articles to collect and exchange data. The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure.

Each device is uniquely identifiable through its embedded computing system and is able to operate within the existing internet infrastructure. Macauley et al (2015) estimate that the IoT will consist of almost 50 billion objects by 2020. Each of these objects will be addressable and, in theory, could have its own Facebook page or Twitter feed – allowing it to report its status in real time.

The history of IoT mirrors that of the internet itself. The first 'thing' connected to the internet was probably the Coke machine at Carnegie Mellon University in the late 1980s. Now in 2017 'things' refer to a wide variety of devices that collect useful data and then autonomously flow the data between other devices facilitating real time control.

IoT is of massive significance to the built environment, especially where sustainability is concerned. As well as being at the heart of building management systems, IoT is one of the platforms that underpin the smart city and smart energy management systems.

5G communications

5G is shorthand for the next phase of mobile telecommunications standards over which there is still considerable debate.

Any new network standard will need to be faster, allow a higher number of simultaneously connected devices, consume less power, provide better coverage, and offer higher reliability in communication.

Given that the standard will need to be able to service significant data usage from, for example, a rise in the number of autonomous vehicles, it is likely that a successful 5G deployment will integrate telecommunication technologies including mobile, fixed, optical, and satellite.

Machine learning and robotics

Samuel (1959) defined machine learning as a '[f]ield of study that gives computers the ability to learn without being explicitly programmed'. Machine learning explores the study and construction of algorithms that can learn from, and make predictions about, data. It is a subset of artificial intelligence. Robotics has moved on from images of tin men and is making inroads into manual occupations.

Ford (2015) identifies artificial intelligence and machine-learning technology that allow computers to make decisions, recognise speech, and visualise in 3D as the main driver of the process. They are leading to the development of algorithms and new robots that can perform all sorts of previously non-automatable tasks.

Research by McKinsey (Chiu et al, 2015) suggests that the impact of machine learning and robotics on jobs is best described in terms of activities rather than occupations, with very few occupations being automated in their entirety in the near or medium term. Instead the impact will see entire business processes transformed, and jobs performed by people redefined.

Susskind & Susskind (2015) challenge the granting of monopolies to today's professionals. They argue that our current professions are antiquated, opaque, and no longer affordable, and are unsustainable in an era of increasingly capable expert systems.

Jobs and activities in the built environment are vulnerable to this kind of technology. At the end of 2015, the BBC, reporting updated research by Frey & Osbourne using UK data, presented a list of occupations at risk . They estimate that valuers, for example, stood a 95% chance that their jobs would be automated by 2035, while surveyors generally saw a 63% chance[2].

2 See BBC (2015) *Will a robot take your job?* [ONLINE] Available at: http://www.bbc.co.uk/news/technology-34066941 [Accessed 21 April 2017]

Building data

Building Information Modelling (BIM) is a process involving the generation and management of digital representations of physical and functional characteristics of buildings. BIM brings together all of the information about every component of a building in one place. It also makes it possible for that information to be accessed for any purpose. At the construction stage, for example, it reduces the risk of mistakes or discrepancies and minimises abortive costs.

BIM data can be used to illustrate the entire building life-cycle from design to demolition and the reuse of materials. Spaces, systems, products and sequences can be shown in relative scale to each other and, in turn, relative to the entire project.

As buildings with BIM implementations age and move into the mainstream, the definitive data provided by BIM will be available to support the optimal facilities management of the building going forward.

Building Management Systems (BMS) are computer-based systems that manage, control and monitor building technical services (HVAC, lighting etc.) and the energy consumption of devices used by the building. They provide sensor-based data and dashboard tools allowing building managers to better understand the energy usage of their buildings and to control and improve operational performance.

Building management systems provide granular data about the operational performance of buildings in real time This, in turn, feeds back into the design process.

Distributed ledger technology

Algorithms enabling the creation of distributed ledgers are powerful and disruptive innovations that could transform the delivery of public and private services and enhance productivity through a wide range of applications.

A distributed ledger is a database of assets that can be shared across a network of multiple sites, geographies, or institutions. All participants within a network have their own identical copy of the ledger. Any changes to the ledger are reflected in all copies in real time. The security and accuracy of the assets are maintained cryptographically to control who can do what within the shared ledger. Entries can also be updated by some or all of the participants, according to rules agreed by the network.

They can underpin other software and hardware-based innovations such as smart contracts and the IoT. Furthermore, their underlying philosophy of distributed consensus, open source, transparency, and community could be highly disruptive to many of these sectors.

Like any radical innovation, distributed ledgers can create threats as well as provide opportunities for those who fail or are unable to respond. The distributed consensual nature of such models may cause them to be seen as particularly threatening. One example of a role affected might be that of the trusted intermediary in a position of control within a traditionally hierarchical organisation such as a bank or a government department.

Underlying this technology is the ‘block chain’. A block chain is a type of database that takes a number of records and puts them in a block. Each block is then ‘chained’ to the next block using a cryptographic signature. This allows block chains to be used like a ledger, which can be shared and validated by anyone with the appropriate permissions.

There are many ways to validate the accuracy of a ledger, but they are broadly known as ‘consensus’. If participants in that process are preselected, i.e. in a closed group, the ledger is ‘permissioned’. If the process is open to everyone, the ledger is unpermissioned.

The real advantage of block chain technology is that it can also set rules about a transaction that are tied to the transaction itself. This contrasts with conventional databases, in which rules are set either at the database level or in the application but not in the transaction.

Distributed ledgers have the potential to be radically disruptive. Their processing capability is in real time, very secure, and increasingly low-cost. They can be applied to a wide range of industries and services including real estate. Proof of concept studies are in progress for land registration for example.

A distributed ledger of properties, including validated building information and ownership, could make the sale of a building investment very efficient indeed, removing the need for agency-style inputs.

2.0 The surveying professional

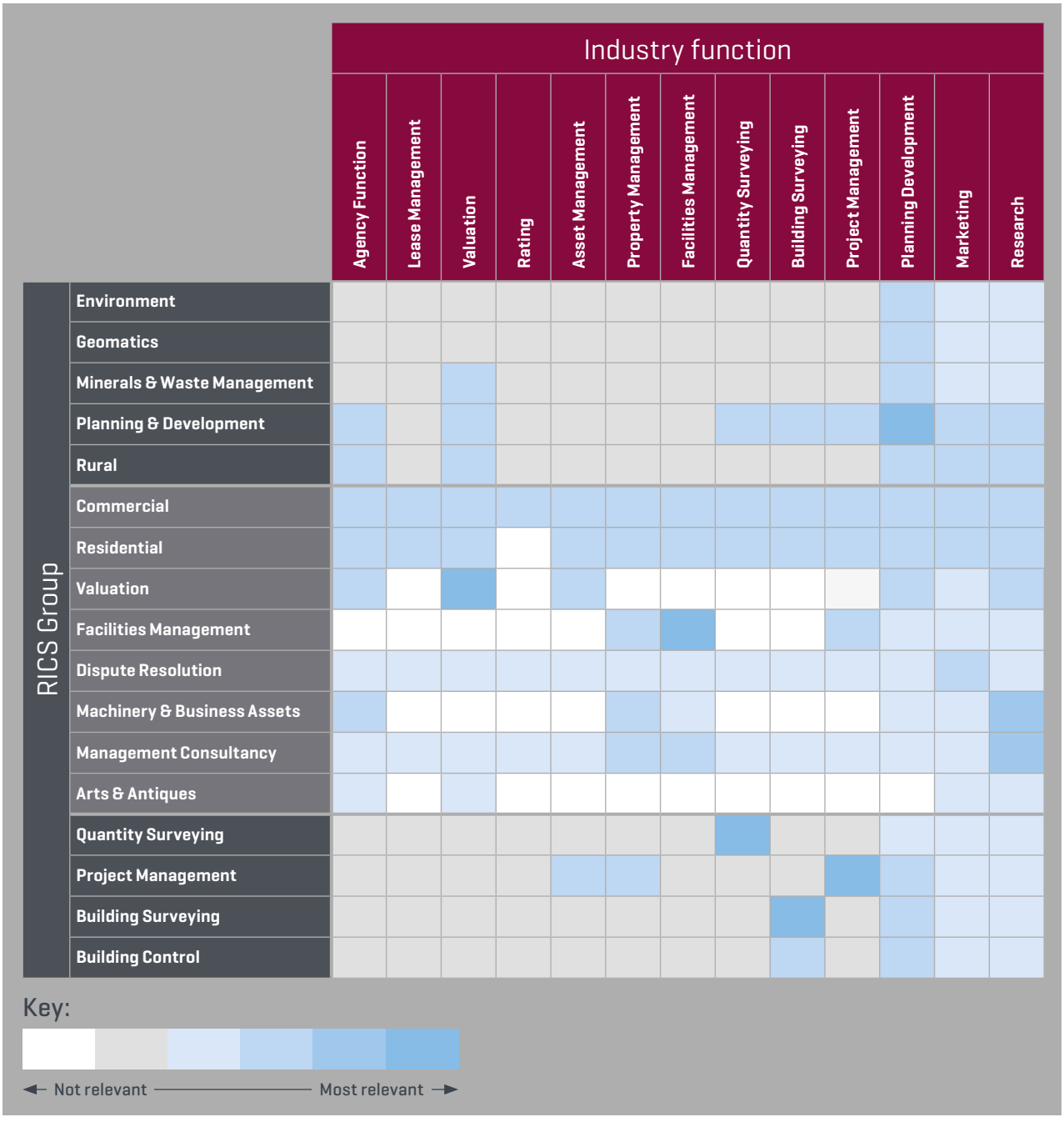
So what does this mean for the surveying professional? RICS organises surveying activities into 17 areas of professional expertise spread across the core sectors of land, property, infrastructure and construction.

In practice, surveying is organised by function – a taxonomy that reflects the different aspects of land use throughout the lifecycle of a building.

Figure 1 shows a skills matrix, setting these functions against the RICS group structure with the coincidence and degree of interests shaded in blue.

The focus of this report is primarily upon the property grouping, excluding art and antiques. However, this is not to say that any conclusions are not of relevance to any other disciplines.

Figure 1: Skills matrix



2.1 The Remit process model

Surveyors are multi-skilled professionals. Each job title will share a set of basic tasks and add to this a specialism. For example, brokers will share a set of common task descriptions covering reporting, monitoring of market information, etc. with other disciplines but will focus on specialist expertise in sales or lettings.

In order to model the impacts of a digital future, this research uses the Remit process model as a guide to break down the functions shown in Figure 1 into a set of 43 tasks. Each task has then been scored according to its content in five areas:

- Data content
- Algorithmic content
- Learning content
- Interpersonal skills
- Physical presence.

These scores are, of course, arbitrary. Although all individual tasks have a defined output, they are generic enough to encompass a great deal of variability according to circumstances. The impact is shown in Figure 2.

2.2 Data content

All functions rely upon some level of data but some are completely data-based. Advances in technology have increased the quantity of data available as well as improving its accessibility, quality, and granularity.

Some of this data is already available – for example, comprehensive land registry data is available in combination with market and ownership data on the same platform – while some will become available progressively through the development process – e.g. BIM datasets for buildings.

As the availability, quality and granularity of data improve, this will facilitate algorithmic functions like valuation to become ever more mechanised.

2.3 Algorithmic content

Some tasks lend themselves better to mechanisation than others. Broadly speaking, the more data that is involved, the more formulaic the task. Appraisal of property values is a typical example but the principle extends to include report preparation using templates and the use of standard contracts through to risk and performance management.

Currently, applications exist that value property mechanically. These are generally not popular as the results are often at variance with market opinion, for example. However, as better data becomes available this will tend to improve. In tandem, machine learning will ensure that the valuation algorithm 'learns' from the use of its output in the real world and improves its results over time.

2.4 Learning content

Many tasks have a high learning content i.e. those undertaking those tasks have been trained to do them. Typically, this learning will have entailed an element of formal learning – a training course for example, followed by experience of the task gained over time.

Technology is disrupting this process radically – in the provision of training itself online, through real time guidance, to the storage of shared experience.

2.5 Interpersonal skills

The set of abilities enabling a person to interact positively and work effectively with others is important to any function but in some areas it is central to a task such as negotiation skills.

Mechanisation affects these skills only obliquely. Communications channels may change, for example, but in that event, interpersonal skills will remain important, albeit with modification.

2.6 Physical presence

There are some tasks that require physical presence although the application of remote technology is reducing the number of these. Although some of these may be at risk from advanced robotics or new materials in the long term, the ten-year horizon of this research is unlikely to see much change.

Figure 2: Task model

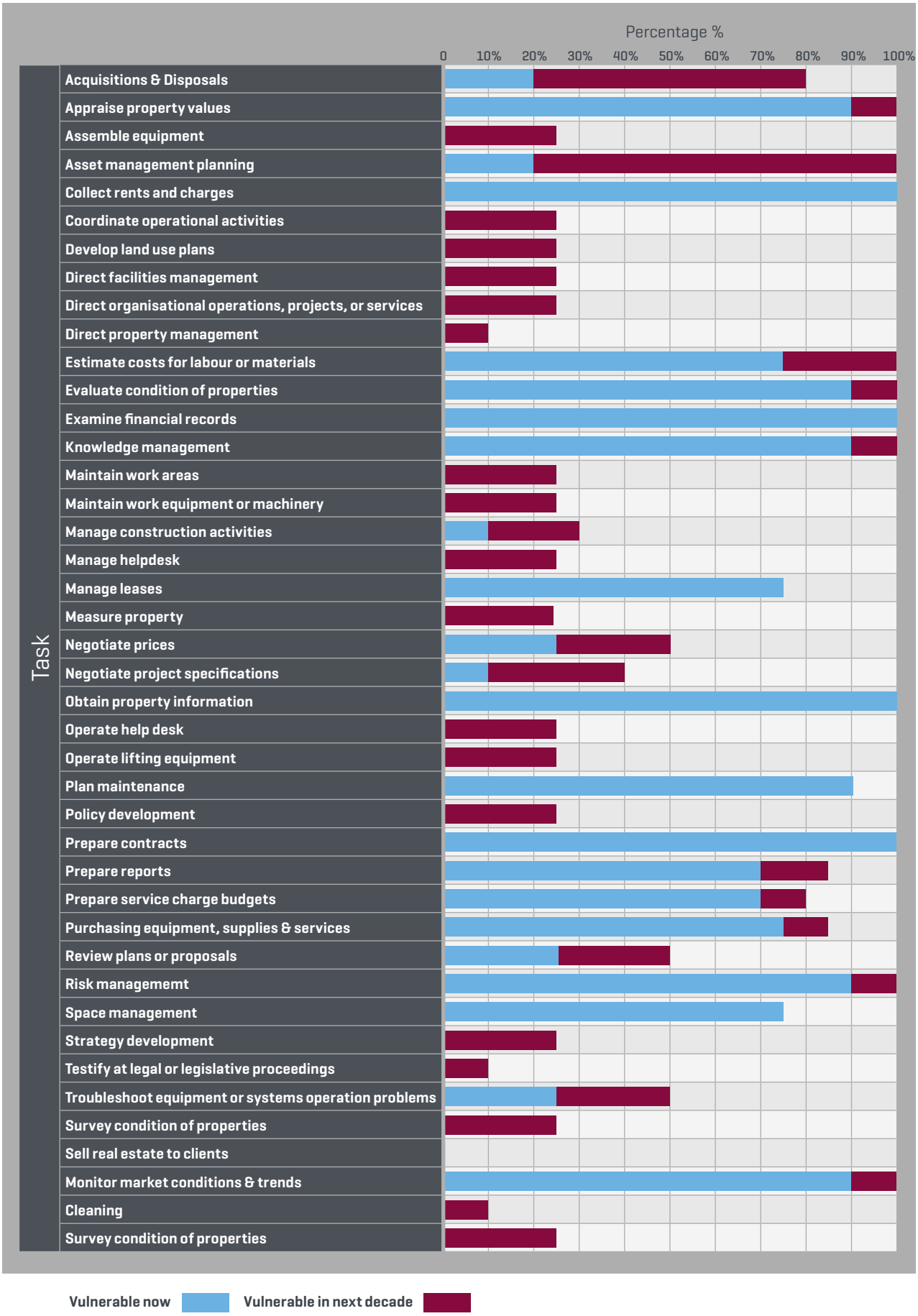


Figure 2 shows the vulnerability of different surveying tasks now and over the next decade. Generally, those tasks with significant 'soft' content requiring interpersonal skills or those necessitating a physical presence are the least vulnerable to changes.

By way of example, the task 'Collect rents and charges' has been at the core of property management for centuries. The original task was based upon the physical collection of rent by an agent, often on horseback, and, for many property managers, this principle still holds true.

Automation of rent collection using direct debits has been possible for around fifty years – hardly high technology – yet traditional methods prevail in many areas. The Remit Consulting REMark survey shows that, consistently, a significant proportion of rent is collected late. This costs the landlord money.

It is manifest that automated rent collection is the way forward.

By comparison the 'Appraise property values' task is largely manual, albeit using software for the actual calculation of value.

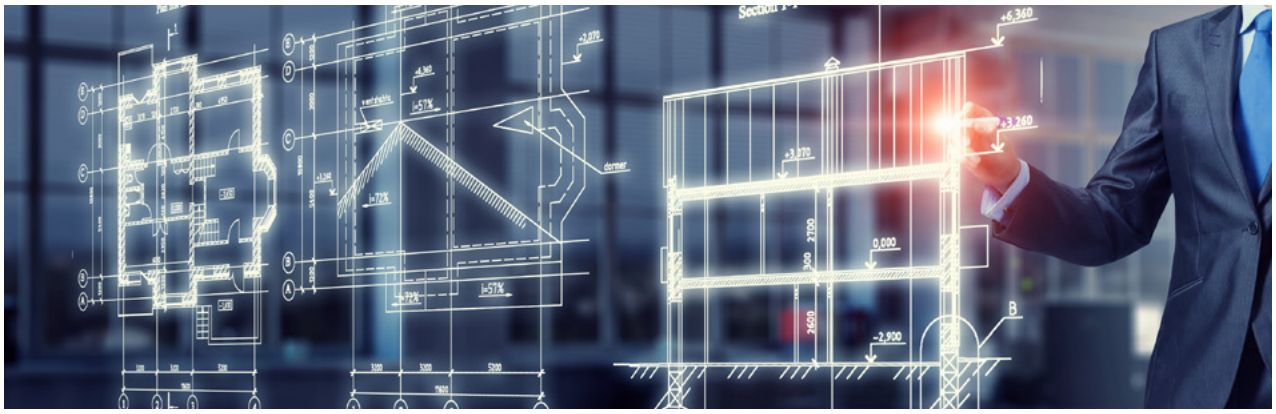
An Automated Valuation Model (AVM) calculates property valuations using an algorithm that examines and analyses large amounts of property data to generate an estimated value for an individual property.

An AVM has several advantages over manual valuation:

- It is always consistent;
- The assumptions, data used, and method are recorded and completely transparent; and
- The valuation can be iterated repeatedly using variations on the parameters at minimal additional cost.

Since the logic of valuation is well described and prescribed, the volume and quality of the data being used becomes paramount. As this improves, the only real barrier to wholesale adoption of AVM technology becomes the ability to indemnify the model as opposed to the individual valuer.

3.0 Surveying the industry



In order to take soundings from the whole industry, an online survey was sent to recipients in late August and early September 2016. 154 responses were received. The results of this survey are shown in Figures 3 and 4.

The questions covered nine scenarios based upon the likely impact of technology in different areas:

- **Data**
  Good data is the cornerstone of effective automation. Currently, in many instances where for example, automated valuation models 'do not work', it is because the data underpinning the algorithms being used is not accurate or granular enough – or both.

  The first question asked in the survey solicited the likelihood that direct real estate transaction data would become completely transparent during the next decade.
- **Valuation**
  Automated Valuation Models (AVM) have been available in parts of the real estate industry for twenty years or more, particularly in the residential sector. Since their introduction they have been refined iteratively and can now handle constraints such as limited data much more sensibly.

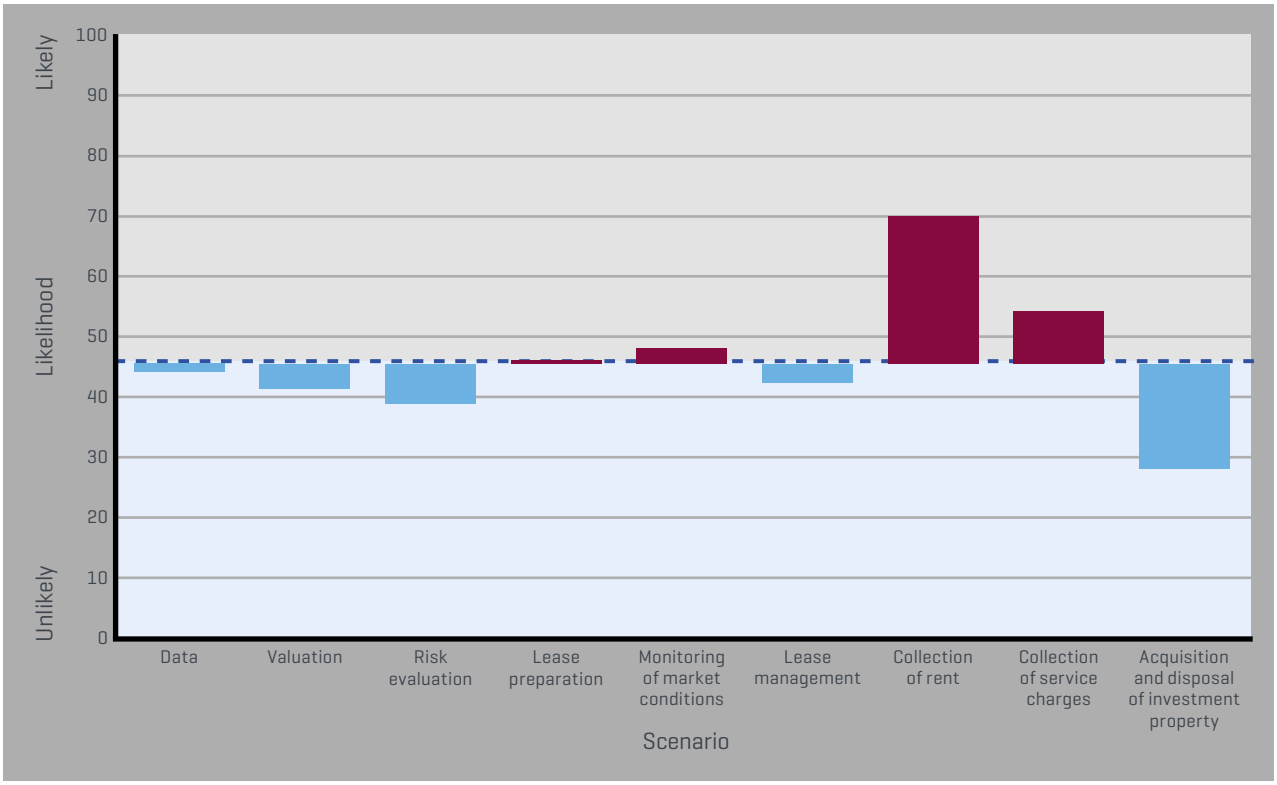
  As data in all sectors improves in accuracy and granularity, it is likely that AVMs will make the transition to commercial sectors particularly for initial valuations, e.g. as part of a filtering process.
- **Risk evaluation**
  Automated risk evaluation models are another area where other investment classes have made significant advances in recent years.

  Given that risk evaluation in real estate is relatively formulaic it seems likely that automated models will migrate into investment decision making over the next decade.
- **Lease preparation**
  Automated generation of standardized contracts is increasingly prevalent in many areas of commercial law. It can only be a matter of time before the automatic generation of standardised leases is commonplace in real estate.
- **Monitoring of market conditions**
  The work of mainstream equity models involves the monitoring of market conditions as a matter of course. The increasing availability of higher quality market data is likely to usher in similar monitoring models into the real estate sector.
- **Lease management**
  A prominent concern for automated lease management is the legacy of existing lease agreements governing invested assets. Recent advances in machine learning have accelerated the ability to read and interpret leases automatically.
- **Rent Collection**
  The automatic collection of rent on the due date via direct debit has witnessed significant growth over the last five years.

  The response to this question is universally positive, with a 70% likelihood of this happening.
- **Service charge collection**
  Although significant improvements have been seen in rent collection, the collection of service charges has not seen a similar improvement.

  The continued codification of the service charge will, however, allow automation to grow in future.
- **Acquisition and disposal of investment property**
  Automated trading models buying and selling real estate assets in real time, underpinned by block chain type technologies, are in all probability some way beyond the horizon suggested – mainly due to data availability and verification.

Figure 3: Average responses by question (Variance from mean)



Respondents to the survey were grouped by speciality then further aggregated so, for example, the Management Group contains those whose speciality lie within the areas of fund, asset, property or facilities management. Such professional services include valuation, corporate real estate (CRE) and lease management.

Responses were solicited as to likelihood on a scale of zero (unlikely) to 100 (very likely). The overall mean across the survey was 46/100.

The most likely area for automation (Figure 3) was felt to be collection of rent which scored 70/100. The least likely candidate, at just over 28/100, was acquisition and disposal of property. The majority of other responses were clustered around the mean.

This is not surprising, given real estate's reputation as the last of the late adopters of technology. What is surprising is that even something like rent collection, which has changed from a largely manual operation to one where a significant proportion is automatic, is not rated more positively.

AVMs are already in use in areas where good data and low risk combine. As data becomes more transparent and more widely available, these models will become significantly more accurate and take more of the valuation load. At some point, they will become accurate enough to facilitate the provision of indemnity insurance – at the same point it will be game over for manual valuation. Despite this, this survey sees automated valuation as unlikely.

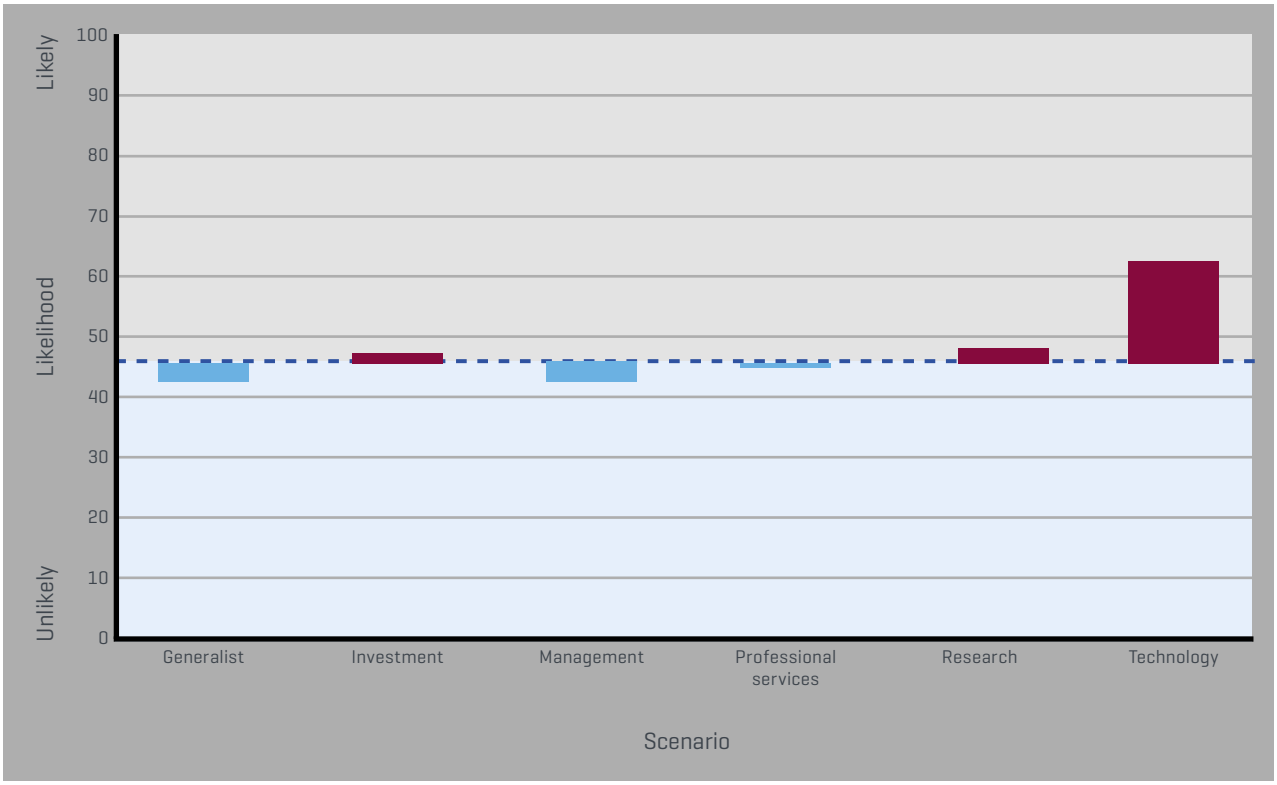
Risk evaluation should be an almost entirely mechanical process. It is an integral part of any investment decision and a key function of any investment committee. Yet in every real estate cycle, clear signals of overheating are routinely ignored as demonstrated by the implosion of CMBS in late 2008 and the popular assertion that 'it will be different this time'. A more rigorous and robust assessment mechanism is long overdue, yet again this is felt to be unlikely by the respondents.

Leases are heavily codified and standardised contracts capable of being generated automatically. This survey shows the jury to be out amongst these respondents about the likelihood of this becoming an automated process.

Monitoring of market conditions used to require the involvement of local knowledge custodians – usually local agents – who were able to nuance and interpret micro movements in local rents, for example. The availability of information has reached the point where, with minimal local intervention, markets can be monitored from another continent. As the quality and granularity of data improves this will become an automatic process. This survey agrees – just.

Lease management is an area where, alongside the mechanics of pricing and renewing, there is a significant element of tenant interaction. Although this latter process is very unlikely to be mechanised, the rest is clearly at risk – but not according to our results.

Figure 4: Average responses by group (Variance from mean)



Looking at responses by group (Figure 4), it is clear that, at 62/100, those specialising in technology are significantly more inclined to see the changes described as likely, as opposed to their traditionalist colleagues. Researchers, academics and investment specialists are also inclined to see these as likely.

Probably the most important question in the survey is the one soliciting opinion about the availability and transparency of transaction data. The fact that most respondents thought that the universal availability of this data was unlikely to happen within the next decade speaks volumes about the (often unsophisticated) nature of the property profession.

Data is everywhere and affects everything that is done in any profession, let alone property. The fact that property data is kept secret (as a matter of course rather than commercial expediency) harks back to the dark days when stockbrokers, for example, made their living by farming data in a manner that would now be regarded as market abuse.

Since insider trading became illegal in 1980, the quality, accessibility, and transparency of equity data has moved on apace. Maintaining these archaic restrictions upon property data – a competing asset class – is unsustainable.

4.0 Implications and transformations

The history of technology tells us that, although disruptive outcomes are possible, they are seldom realised in the short term. This is particularly true of property in its widest sense, which has embraced technology but at a relatively slow pace.

The Fourth Industrial Revolution is likely to ensure that, this time, things will be different.

Eric Schmidt, erstwhile CEO of Google, makes the point that we are moving, in a single lifetime, from a small elite having access to information to essentially everyone in the world having access to all the world's information (McKinsey, 2013).

Such a change has wide-ranging implications for privacy, communications, security, human behaviours, the way in which information is used, and for professions based upon privileged access to information.

The model that was shown in Figure 2 breaks 'surveying' into 42 key tasks based upon Remit's best practice process modelling. Each of these is then assessed as to the proportion of the job at risk from technology now and within a decade. Clearly, these assessments are, to an extent, arbitrary but they are relatively robust being based upon current knowledge and practice.

The exercise shows that 11 of the tasks identified are 100% at risk over the next decade. These include rent collection, valuation, risk management and monitoring of market conditions. A further 7 tasks are more than 50% at risk and 22 tasks see 25-50% of their processes at risk over the same period.

The burden of this risk is likely to fall disproportionately on the commercial property, residential property, and valuation sectors but facilities management is also likely to be affected significantly by sensor-based technology around the IoT.

At a functional level the impact will be especially disruptive in the areas of lease management, valuation and property, and asset and facilities management, and will be seen in different ways:

- An increase in the consistency, transparency and timeliness of transactions, be they lease events, valuations or collections. Interactions with tenants will be informed by online information in real time, for example;
- A step change in the accuracy and timeliness of reporting. Investors will monitor portfolios in real time, for example, reducing the management overhead;
- An explosion in the number of sensors deployed under the IoT umbrella will increase the visibility and responsiveness of all buildings – not just new ones – and facilitate remote facilities management;
- A reduction in the cost of managing a portfolio of buildings. Redeployment notwithstanding, it is likely that the headcount in particular areas – valuation for example – will be reduced significantly; and
- A change in the skillset required. Surveyors are likely to become either data scientists or client managers. This has implications for real estate education going forward.

Longer term, this revolution paves the way for property to compete on a level playing field with other asset classes. Rather than being a large, inelastic, and inflexible asset, this offers the potential for property to become a wholly securitised, flexible, and dynamic asset underpinned by its residual value.

5.0 Alternative futures

Any future is uncertain and the rapid pace of technological changes makes any long-term prognosis a challenge. As we have seen, the potential implications of the Fourth Industrial Revolution are significant for the property sector. However, as with any change, a great deal hinges on how readily it is embraced and adopted.

Technology is a great enabler and has facilitated significant change in the economic, political and social landscape. Digital services has proved to be one channel through which change can be enacted.

Three scenarios are presented here that reflect different potential futures - not for technologies per se but for the reaction to them. The assumed time horizon is in the next the ten years, from 2017 to 2027.

5.1 Scenario 1 – A creative divide

A company's most important asset is its creative capital. Creative employees pioneer new technologies, create new industries, and drive economic growth. Research for the Harvard Business Review (Florida & Goodnight, 2005) found that, in 2005, professionals whose primary responsibilities include innovating, designing, and problem solving made up a third of the U.S. workforce and accounted for half all wages and salaries.

Yet not everyone is creative, nor does every situation require creativity. There is a clear divide between those who are active participants and those who are passive recipients. This divide extends into activities as well as personal preference, splitting processes between the creative and non-creative.

The reversion scenario sees a growing digital divide emerging between these two groups. Active participants will drive creativity and innovation forwards, leaving passive recipients with second-rate services.

A good example of the divide is seen with television. Linear television broadcasting started in the UK in 1936 as a public service free of advertising. Even as recently as 2000 the number of channels available to viewers was very restricted without access to relatively expensive cable connections or satellite dishes. In 2017 there is a collection of free-to-air, free-to-view, and subscription services over a variety of distribution media, through which there are nearly 500 channels available to consumers.

Sitting on top of these channels are rafts of on-demand tools that simplify and classify content and allow time-shifted viewing. Despite this apparent complexity, for most viewers watching television remains essentially a passive pastime. Growth in interactivity, such as for adverts, has not emerged as quickly as forecast and remains at the experimental stage.

In early 2016, the BBC switched one of its most innovative broadcast channels to online-only in response to cost pressures. BBC 3 is now available on demand only with no linear content. This moves viewing from wholly passive to active selection and from a recipient audience to a participant one.

Hardware has already begun to follow this path. Gartner Group (2016) estimate that around half the computing devices shipped in 2015 (excluding phones) were tablet computers i.e. devices geared around consumption of content rather than creation. With the exception of picture capture, smartphones are also devices for consuming content as opposed to laptops or PCs geared to content creation.

Digital services are flexible enough to cater for both participants and recipients but some trends in technology may bear down disproportionately on the recipients group. In particular, machine learning will impact employment in those activities lacking any creative dynamic.

As far as property is concerned, creative workspace is a different animal to space designed for consumption of content. Research by Ramidus Consulting (2015) for the City of London found that workplaces are powerful conveyor of messages to staff and clients about the values and culture of an organisation.

Companies often use their office space as a means of expressing their culture and identity, and consequently tend to value high specification and tailored fit-outs. This scenario sees the participants group leasing less Grade A office space, reflecting their need to keep rental expenditure to a minimum and spend more on the fit-out to encourage interaction and differentiate it from competitors. The recipients group, under pressure from automation of the non-creative processes, are also less likely to pay premium prices for space.

From the perspective of real estate professionals, the implications are that soft skills and applied creativity in areas like customer interaction will take precedence over applied skills such as valuation that will become largely automated.

5.2 Scenario 2 – technology backlash

In 1812, an uprising of workers swept the UK, igniting a number of protests and armed raids. The so-called Luddites raided mills and destroyed machinery. According to historical records, the Luddites were largely male and members of the working class employed in professions such as knitting and weaving. The workers were not so much fearful of technological advances as they were concerned about machines replacing their own manual labour.

In *Rebels Against the Future*, Sale (1996) explores the lessons that may be learned from the Luddites with respect to the ubiquitous use of technology. Neo-Luddism can be described as any modern philosophy that is fearful or distrustful of the changes that will be brought about by technological advances. The principal theme is that the technology has evolved to control, rather than to facilitate, social interactions, threatening to dehumanise the process. In some respects, the Maker Movement can be seen as anti-technology although many of its artisans use technology extensively.

In this scenario, this backlash gains traction and begins to affect the number of technology users and the nature of their use. If sufficient scale were reached this could see falling sales of hardware and falling numbers of users of digital services.

From the standpoint of the built environment this would be unlikely to generate a wholesale move back into conventional uses of space. Despite a backlash, engagement with technology at some level would be inevitable as it has permeated into the very fabric of buildings. Growth of the Internet of Things will make that ever more apparent and the impact of machine learning will continue to erode employment prospects in certain areas.

The dilemma for the property professional is that real estate is not a field in which craft skills can easily be deployed and, consequently, the same move away from hard skills to soft ones will apply.

5.3 Scenario 3 – engagement

The idea of understanding a consumer's needs before they actually needed what Apple was making has remained a hallmark of the company throughout its history. The idea of empathising with a consumer before a market was even developed set the company on the path of always looking forward to find how people would behave and made it, in 2016, the world's largest company.

Over the last decade particularly, technology has moved from facilitating the automation of repetitive processes to becoming an integral part of everyday life.

Even the not-so-technology-inclined cannot avoid interfacing with technology at some stage, wittingly or unwittingly. Technology has become embedded in the fabric of society.

In this scenario, a digital future and the technology underpinning it continues to evolve, in this way changing the built environment, working practices, and the number and quality of jobs.

The evolution of the 'Internet of Things' will deliver much better operational data on buildings and will make the built environment a much 'smarter' place, increasing permeability between the public and privately-held data.

Ameliorated data will feed better algorithms that in turn will make the management of the built environment significantly more efficient. The downside here is that activities built upon those inefficiencies will become automated and jobs will disappear.

Distributed ledger technology will begin to disrupt processes built around centralised control of data, democratising the process, reducing costs, and leading to significant new opportunities to manage and control space.

In this scenario, the property profession sees root and branch reform starting with the education process to place the customer at the forefront of all activity. This would of course be supported by technology as the means of execution.

6.0 Conclusion

Perhaps uniquely in the history of work, the availability of digital services has enabled individuals to brand themselves on an equal footing with corporates. This encourages individuals to see employment as a portfolio of jobs (Brown, Hesketh, & Williams, 2004) and moves the relationship between employer and employee away from monogamy. It may even presage the death of the contract of employment in favour of a more specific contract of service.

This implies that there will be even greater mobility in the workforce in the future than is seen even now, making it ever more important that we understand the changing nature of the link between workspace and workplace.

Since 2008, the Internet has grown and diffused rapidly across the globe, bringing significant benefits to economies jointly and severally. The digital economy now permeates many parts of the world economy, impacting sectors as varied as banking, retail, energy, transportation, education, publishing, media and health. Internet-based processes are transforming how social interactions, business and personal relationships are conducted.

The mobile workforce is unlikely to be constrained by country or geography. The advent of high quality communications in the Third Industrial Revolution has already facilitated the movement of industries such as software development to global sourcing. The fourth is likely to accelerate this trend, with industries moving on the basis of available skills. This holds lessons for the future location of real estate and real estate professionals.

The impact of digital services on the surveying industry will be as significant and disruptive as it will be for any profession. The physical nature of buildings has insulated surveyors from previous revolutions, buying time to allow evolution. The Internet of Things, for example, combined with building management systems and Building Information Modelling removes that layer of insulation and exposes surveyors to rapid, discontinuous change.

As has been identified, the remit of a surveyor covers a multitude of skills and specialisms. This research highlights those areas where the impact will be seen soonest and gives a view as to likely effects over the next decade.

Clearly, there are obstacles along the road ahead. History tells us that just because technologies are available it does not mean that they will be adopted wholesale. However, with higher efficiency comes reduced cost and increased timeliness and it is highly likely that some functions will be heavily impacted by the logic of that argument. These technologies will be available to clients and their expectation will be that surveyors will be able to add value using those tools.

Another lesson from history is that the mechanisation of one job does not necessarily mean that it disappears completely. Remit Consulting's Remark research into the property management sector has catalogued a significant change in the balance of employment between fewer property accountants and more surveyors as the function changes from a hard mechanical rent collection process to a softer one of managing customer relationships.

Any task that has at its core data processing overlaid with learned skills is at risk. Any task that is primarily to do with interpersonal relationships is unlikely to be so affected.

None of these potential changes appear to cut much ice with the industry. The survey shows that, on balance, practitioners see most of the changes postulated as more unlikely than likely to come to fruition. Researchers and technologists are generally more positive with regard to change but other disciplines are much less positive – even in areas like rent collection.

Time will tell whether this is pragmatism or denial but technology is an area in which the property profession generally lags behind its customers. The survey shows that there is little perception of an appetite for change amongst customers – but this can change very quickly.

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