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A Strategic Development Document Investigating the Impact of Digitisation and Digitalisation on Cost Management in the Construction Industry, and more Specifically Rider Levett Bucknall by 2030

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DECLARATION

I declare that I have personally prepared this report and that it has not in whole or in part been submitted for any other degree or qualification. Nor has it appeared in whole or in part in any textbook, journal or any other document previously published or produced for any purpose. The work described here is my/our own, carried out personally unless otherwise stated. All sources of information, including quotations, are acknowledged by means of reference, both in the final reference section, and at the point where they occur in the text.

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EXECUTIVE SUMMARY

This research study focusses on RLB UK Ltd, a professional services business based within the UK that provides professional services to the construction industry. The purpose of this research is to investigate the impact of digitisation and digitalisation on the Cost Management profession and how any risks can be mitigated, and opportunities capitalised on. As 60% of RLB's turnover is derived from this role it is important to identify incoming technologies and legislation, recognise any threats from these and make recommendations on how to mitigate the risk and capitalise on opportunities. The study draws on industry and academic literature and response from interviews.

The research is conducted as a thematic analysis of responses from semi-structured, open interviews with fifteen subject matter experts from RLB and the wider construction industry.

From the review of academic and industry literature some initial themes were identified, these were used to produce a number of questions to delve deeper into these themes and garner insight from the SME's.

From coding of the transcripts and subsequent categorising of the codes, six higher order themes were discovered, these were: Change Management, Data Strategy, Digital Skills Gap, Digital Trends, Industry and finally Workforce Planning.

Through analysis of responses relating to the above themes, three key areas of risk to the business were identified: the value placed on data by the business, the positioning of the business to achieve its digital aspirations, and finally the digital skills gap.

To mitigate these risks the following courses of action are recommended:

1. Implementation of a data strategy to support the business for future digital innovations
2. Undertake a Board level review of the business' digital ambitions and determine the position of RLB in terms of digital innovation and adoption
3. Create a strategy to plug the existing and future skills gap though alignment with nascent digital positioning and data strategy by collaborative work with the Board, HR, and L&D functions of the business.

1 INTRODUCTION

1.1 OVERVIEW

This exploratory research study investigates the implications of the digitalisation and digitisation on the architectural, engineering and construction (AEC) industry and in particular the cost management profession.

1.2 INDUSTRY CONTEXT

The Construction sector accounts for roughly 6% of the economic output of the UK and £117b per annum (Green, 2020), with approximately a quarter of the output being public sector and three-quarters private sector. The industry can be divided into three main sectors: commercial (45%), residential (40%), and infrastructure (15%) according to The Cabinet Office (2011). Nearly 60% of total construction productivity is new build, whilst 40% is refurbishment and maintenance. Furthermore, it accounts for 10% of total UK employment divided over the following areas: Contracting, Services and Products (Department for Business, Innovation & Skills, 2013).

The construction industry is ranked as one of the least-digitised industries, above only agriculture, and hunting (*2020: The year construction turns a corner*, 2019). This is further illustrated against other industries in Figure 1.1.

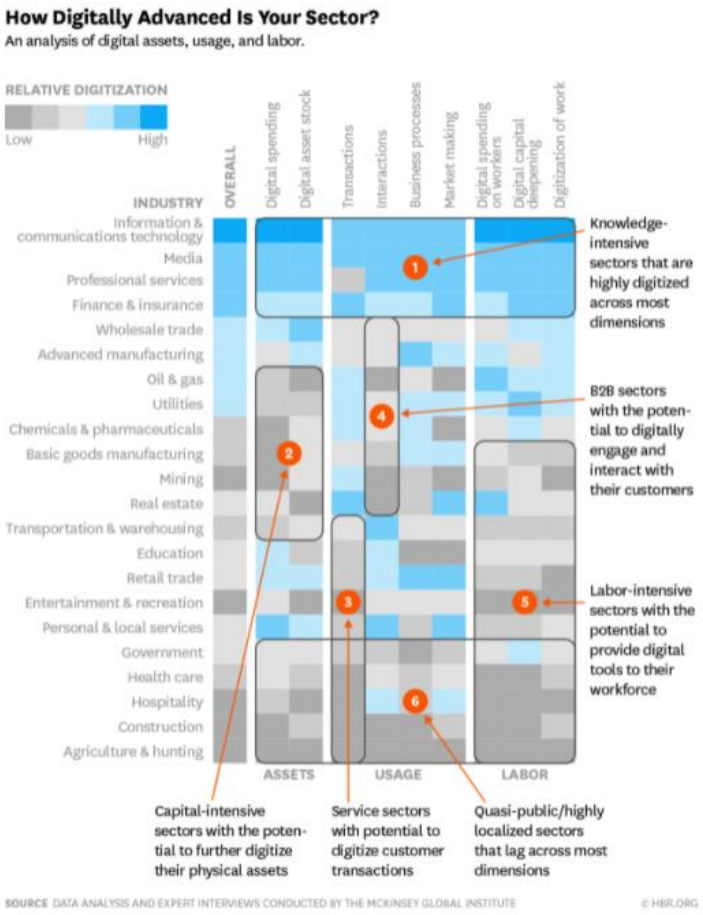

Figure 1.1: Levels of Digital Advancement by Industry

1.3 RIDER LEVETT BUCKNALL

The organisation this study centres on is the UK element of Rider Levett Bucknall (RLB), an independent global construction and property consultancy providing management and advice throughout the built environment. Consistently ranked within the top consultants, RLB is 100% employee owned allowing independent advice and the freedom to focus on investment on its people and the industry.

Within the UK, RLB has a headcount of 850 and operates nationally and across all regions. RLB's service offerings fall under four areas: Cost Management and Quantity Surveying, Project and Programme Management, Building Surveying and Specialist Solutions such as sustainability, carbon and wellbeing, and social value. These services are available to all sectors and services, within both the public and private sector. RLB's clients range from supermarket chains to global tech companies, and with a large base of public sector clients such as the Department for Education and the NHS.

RLB UK has a turnover of £77 million per annum with 60% of the business turnover attributed to the cost management/ quantity surveying service.

1.4 THE ROLE OF THE QUANTITY SURVEYOR/ COST MANAGER

Quantity surveyors (QS), also known as construction cost consultant, cost manager or commercial manager, handle the costs relating to building and civil engineering projects, from the initial calculations to the final figures. As part of the role, they try to minimise the cost and risk of a construction project and enhance value for money, while still attaining the requirements for legal and quality, for example ensuring compliance with building regulations.

The role requires the preparation of estimates and costs of the work (called Bills of Quantities) and when the project is in progress, the tracking of any contract variations that may impact costs (Prospects, 2020).

1.5 IMPACT OF THE CURRENT CIRCUMSTANCES

The future of the built environment will be data-centric and digital (Broo et al, 2021), therefore it follows that there will need to be an overhaul of skillset required by new and existing QS to encompass an understanding of technology (RICS, 2019), and particularly digital skills in the guise of data analytics (Seidu, 2019).

RLB has already highlighted a range of technologies which they are actively investigating, as noted in Building Information Modelling and Digital Technologies (RLB, Unknown). These include but are not limited to, virtual reality (VR), augmented reality (AR) and cloud-based integration platforms able to hold a single point of truth for project data.

No individual technology will transform the sector, rather there is a need to develop the aptitude to embrace technology to enable the performance and progression required to maintain pace with technological advances (RICS, 2020).

A major concern to profit margins in the construction sector is the entry of Big Tech. They are better financed and resourced and therefore have an increased opportunity to leverage those resources to the detriment of long standing and smaller businesses. The convergence between Tech and Built Environment (BE) is evidential, with Tech companies now applying machine learning to data in the BE (RICS, 2020). Reports suggest that currently the companies applying AI to analyse previous pricing information are recording profit margin gains (Koelman, 2019). This indicated that the ability to exploit new technology for value realisation relies heavily upon the capability of the QS to astutely utilise the data they hold to extract maximal value and profit (Seidu, 2019). A 2020 RICS report similarly note that the pace of technological change fuelling the digitisation of the built environment

via technologies such as digital twins and blockchain is emerging from organisations not traditionally a component of the property industry (RICS 2020).

This slow uptake of digitisation and incorporation of digitalisation sees construction in its current form expiring (RICS, 2020). Emerging technology entails a diminishing rationale for certain existing cost manager skills, as it becomes apparent that an automated function can provide a more accurate piece of work. The function could move to a paid for output model therefore in the future, as opposed to the current business model where the surveyor is paid for their time by the client. It could become a self-service model ultimately. This would be game changing for the industry, and for staffing, feasibility, and profitability, not least with the current job role of QS becoming superfluous to requirements. This therefore necessitates a thorough investigation into, and examination of the implications of digitisation and digitalisation on RLB, and considerations as to how to reposition for the inevitable changes is vital to the health and sustainability of the business.

1.6 STATED AIMS AND OBJECTIVES

This project sets out to investigate the Impact of Digitisation/Digitalisation on Cost Management in the Construction Industry by 2030, in order to understand the implications in relation to the architectural, engineering and construction (AEC) industry and more specifically RLB.

The research undertaken as part of this project will inform the wider digital strategy of the business by:

1. Horizon scanning innovations in digital technologies in relation to the cost management profession
2. Evaluating the impact of the key digital trends within the industry on the cost management profession
3. Assessing areas of risk to the business and investigate how they can be mitigated
4. Make recommendations to capitalise on opportunities identified in the research

1.7 PROJECT STRUCTURE

Following on from the introduction in chapter one, the study takes the following structure:

In Chapter two the existing literature will be reviewed from both industry and academic journals to identify the main themes, concepts and frameworks and their impact on the previously stated aim of the project.

Chapter three discusses the methodology and theoretical framework used. The application of the selected research approaches will be justified, and the wider research design discussed including the ethics and limitations.

Chapter four presents the results and findings from the qualitative research in the form of coding tables along with short narratives introducing the findings and pertinent points.

Chapter five discusses the results and what these results mean when triangulated with the literature. Main points and observations are highlighted and how they relate to the research aims and objectives. The implications of the research studies findings are discussed and the impact of these on the organisation.

In chapter six the conclusion of the research study is discussed and how the findings answer the aims and objectives number of recommendations put forward to capitalise on the opportunities identified.

2 LITERATURE REVIEW

2.1 INTRODUCTION

The following literature review undertakes an evaluation of the available literature from both academic and industrial sources allowing the identification of key themes, concepts and frameworks relating to the identified aim of investigating the impact of Digitisation and Digitalisation on Cost Management in the Construction Industry by 2030 and satisfy the objectives of horizon scanning innovations in digital technologies in relation to cost management, evaluating the impact of the key digital trends within the industry on the cost management profession, assessing areas of risk to the business and analysing how they can be mitigated, followed by making recommendations to capitalise on opportunities identified in the research.

As per Hapon (2020), **digitisation** can be defined as" *...the process of converting information from an analog to a digital format",* whereas "***digitalisation*** *is the use of digital*

technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business" (Gartner, no date).

Upon review of the contemporaneous academic and industrial literature available pertaining to the digitisation and digitalisation, there are a number of emerging key themes, digitalisation of the construction industry, industry standards, strategies, and government recommendations, component parts of digitised and digitalised construction, and finally the digital skills gap.

2.2 THEME 1 – MODERNISE OR DIE

The 2016 Farmer review of the UK Construction Labour Model (Farmer, 2016) highlighted that the construction industry is in dire need of change. The report was seen as a call to arms to take an introspective look at a sector deemed to lack technological adoption, innovation and collaboration, while being unprepared for worsening skills and labour shortages. This outlook later evolved into Digitise or Die (Windpassinger and Tricoire, 2017).

Following on from this the UK Government not only incorporated the findings into future policy development (HM Government, 2017) but outlined a number of responses to the recommendations in the report.

The lack of technological adoption highlighted in Farmer's report correlated with a 2020 index by McKinsey cited in Construction News (Rijdt, 2019) ranking construction as the third least digitised industry. The slow uptake of digitisation and incorporation of digitalisation in the construction industry risks it sleepwalking its way into obsolescence (RICS, 2020). There is significant potential for companies that already have a digital native core to enter the construction industry and disrupt it (PWC, 2020; ArchDaily, 2020), further reducing already low profit margins (Kavuri, 2020). The impact of this would be felt widely across the UK economy and labour market.

The impact of falling behind or not undertaking a digital transformation of the construction industry, which accounts for roughly 6% of the economic output of the UK and £117b per annum (Green, 2020), could lead to a stagnation of the UK industry compared to other countries and low productivity. Whereas the well-managed digitalisation of the industry would not only improve building performance, reduce impact on the environment, and deliver better public and social services (Boulton and Kirsten, 2019), but also improve customer satisfaction and provide possible new avenues of income (Kaufman et al, 2018).

Farmer's findings are further corroborated in the CECE report (Digitalising the Construction Sector, 2019) that digitalisation of the construction industry is a more complex issue than introducing digital technologies.

A further complication is due to the size of the supply chain and misalignment of stakeholders, meaning they would all need to step up at the same time and not in a piece-meal fashion. However, as there are 270,000 business employing 2.6million workers, directing them all to move in unison would be near on impossible, but giving a common direction of travel, irrespective of business size is key (pbctoday, 2018). Green (2016) argues that not addressing wider stakeholder complexities by Farmer fails to engage with many of the nuances particular to the industry.

2.3 THEME 2 – INDUSTRY STANDARDS, STRATEGY, AND GOVERNMENT RECOMMENDATIONS

Very little around digital transformation has been mandated in UK law. As a development from the first Government Construction Strategy from 2011-15 (Cabinet Office, 2011) where £3 billion of efficiency savings were enabled through the use of cross-government data to benchmark costs and the development of digital capability in design and construction to procure assets using Building Information Management (BIM) Level 2. The subsequent 2016-20 Construction Strategy (Infrastructure and Projects Authority, 2016) mandated construction firms to be certified to BIM Level 2 (or working towards) to work on public sector projects. We know from the Government Construction Pipeline published biannually by the Infrastructure and Projects Authority (IPA) there is continued commitment to invest in construction, therefore the BIM L2 requirements could be seen as a strong motivator for many construction companies to undertake certification. This can be backed up by research; the UK has the highest number of construction companies utilising BIM at level 2 compared to Europe (Steers, 2021 and Paul, 2018). However, as indicated in The NBS BIM Report 2020 (NBS, 2020), only 62% of smaller quantity surveying practices with 15 or less staff have adopted BIM, compared to 80% of those with 50 or more staff.

UK Government is now focussed on embedding BIM Level 3 as a strategic priority (Government Construction Strategy 2016 – 2020). This next level supports a fully integrated, collaborative process for all members of the supply chain and came under the remit of the Digital Built Britain Strategy (HM Government, 2015). This further highlights the UK's focus on maintaining their position as being world leaders in BIM and their drive to digitise construction. This was additionally made a Strategic Priority in the Construction 2025 report to be "efficient and technologically advanced" (HM Government, 2013, pp.4).

The increasing levels of BIM will focus on enabling improvement and embedding new systems and technology moving from a deterministic model at Level 2 to an agile, future-proofed model such as management of assets and the foundational design and construction (RICS, 2020). These will not be a legislative requirement. There is currently little buy-in to level 3 due to the stipulation of a central "BIM hub" to exchange information between parties. Furthermore, most organisations use a Common Data Environment (CDE) generally specific to each organisation, whereas in level 3, a central, cloud based CDE would need to be available. This presents a problem as to whom would be the custodian of this environment. Were BIM Level 3 to be achieved, a single building model could be produced and stored in the cloud allowing collaboration from all stakeholders over the whole building lifecycle (Terol, 2020).

Noted in its strategy document for level 3 BIM, there are unknowns from a free market perspective with the document stressing that while incredibly hard to quantify the market opportunities that could be created by the adoption of BIM Level 3 and beyond, it is vital that the construction industry is clear as to the scale of opportunities to justify future collaboration and buy in (HM Government, 2015).

To achieve BIM Level 3 the industry needs to upskill its professionals at all levels and across all sectors. This necessitates a dramatic shift in mindset in the construction industry. The key driver is collaborative working in a format that is rewarded. (Terol, 2020)

In the Government Construction Strategy 2011 (Cabinet Office, 2011) it was identified that the adoption of BIM Level 2 would be hindered due to the lack of compatible systems, standards, and protocols, therefore The Cabinet Office were instructed to co-ordinate the development of standards with wider industry, thus allowing supply chain members to work collaboratively in BIM. These new standards, known as the UK 1192 Series, were later elevated to international level through the International Standards Organisation. These new international standards, built upon 1192 are called ISO-19650 with the final revision being released in 2019. As a result of this new international standard, a level playing field was created for all organisations and suppliers around the world to compete, innovate and collaborate irrespective of geographic location (Sjogren, 2021).

Several sources examine the implementation of ISO 19650 and the impact on the wider agenda of Construction 4.0. The Chartered Institute of Architectural Technologists (CIAT) note a number of barriers to transitioning to ISO 19650, namely obfuscation and insufficient understanding of the standard requirements by the client (Ford, 2019). It was noted that the absence of level of detail, definition, development, and information need around the ISO will and has caused much consternation and disappointment. However, this level of guidance

was beyond the scope and intention, potentially leading to significant industry risk around the precise information needed (Fitz, 2019).

GIM International, the global source on new developments and applications in geospatial surveying take this further by noting successful implementation will not only necessitate strong change management in the contractors delivering the project, but there will be a requirement for the clients to revolutionise the modes of production, interchange and application of digital information (Gregory, 2020). RICS 2020 Future of BIM report goes some way to address these issues by offering a clear, chronological action plan to move businesses forward in their BIM journey (RICS, 2020).

The latest National BIM report has indicated 26% of organisations have already adopted the BS EN ISO 19650 standards (NBS, 2020). Furthermore, the report identified a shift from the previous year and survey respondents as likely to use BIM on private sector projects as public sector (in fact, for refurb and new build projects the BIM report 2020 respondents indicated that 77% used BIM on private sector projects against 62% on public sector) which is interesting as Level 2 is mandated by the Government primarily for public-sector projects and therefore could be seen as an indicator that the industry is seeing the benefits outweighing the challenges of applying BIM principles and processes (NBS, 2020).

The report goes on to further highlight the indisputable increase in the use of the BIM principles and the subsequent standardisation through the ISO, noting particular benefits in risk reduction and profitability, and the added advantage to the global uniformity. Significant progress in structured data stored in publicly accessible cloud repositories and information from manufacturers existing solely in digital formats possibly further demonstrate the onboarding of the industry supply chain to these ways of working (NBS, 2020).

BIM and the standardisation through ISO-19650 are foundational to the concept of Construction 4.0 which is viewed as construction's branch of Industry 4.0. This concept was coined by the German government in 2016 and as a transformational framework to support the development of their industrial sector (Nowotarski and Pawlawski, 2017). The basis of this is to maximise the potential of new technologies and ideas. More specifically to construction, to converge existing and emerging technologies within a specified framework (Irizarry, 2020) and to further drive the digitalisation of the construction industry (Alaloul et al., 2020). Industry 4.0, as described by McKinsey Global Institute as the age of "cyber-physical systems" i.e., systems that integrate computation, networking, and physical processes, and include a variety of technologies that cover mobile devices, the Internet of Things (IoT) artificial intelligence (AI), cyber security, robotics, and 3D printing (Buguin, 2013). It is through the exploitation of these elements caused by the massive digitisation of

information, material processes and large amounts of data in digital form collected by various sensors, cameras, builders, and users that will transform the built environment (Klinc and Turk, 2019). Underwood and Isikdag, (2011) note the lag in terms of investment and adoption in these technologies which was further ratified 8 years later by Aripin et al. (2019) cited in Perrier, et al (2020).

However, although a recent concept, Construction 4.0 is evidentially attracting substantial global attention, notable from this literature review by Forcael et al (2020).

Once more, though similarly to the adoption of BIM and ISO-19650 the fragmentation of the supply chain and limited capabilities of leadership and change management in the industry are holding back greater moves towards meaningfully implementing this framework currently (Alaloul et al., 2020).

Perhaps, the major UK driver for further uptake of the above recommendations and frameworks, collaborative and holistic building information sharing will be the implementation of the findings in the UK Government commissioned 2018 Independent Report of Building Safety (Hackitt, 2018). In response to the Grenfell Tower tragedy in June 2017, an independent review of building regulations and fire safety was undertaken. A key recommendation is the mandating of a digital (by default) standard of record-keeping for the design, construction, and occupation of high-rise residential buildings. It proposes this data must be maintained, post completion handover for facilities management as well as identifying manufacturer, installer, and maintenance requirements for any building materials. This concept, now called the Digital Golden Thread is seen as vital to record keeping and maintaining the building's information throughout its lifecycle (Ministry of Housing, Communities and Local Government, 2021; Buro Happold, 2021).

The major concern is the time and cost required to implement the recommendations and whether they will be legislated for (Spinardi, 2020).

2.4 THEME 3 – COMPONENT PARTS OF DIGITISED AND DIGITALISED CONSTRUCTION

Boulton et al (2019), state that BIM is a key driver in the enablement of digitalising the construction sector. Certainly, this is the view of the UK Centre for Digital Built Britain (CDBB), (Broo et al, 2021). Furthermore, both groups denote those other technologies have an equally important role in the digitalisation of the sector, such as big data and its analytics, the Internet of Things (IoT) and machine learning (Klinc and Turk, 2019). Outlining these individually, what is big data in the context of construction?

Big Data for building and construction already exists in the records and plans of built assets. This data can originate from a range of sources and people, in fact any data generating end point. Existing building information can continually be built on with input from building life cycle maintenance and other product manufacturers in the supply chain. Big data use and interpretation assists in decision making and increased insights, not just in the construction phase, but in the design phase to provide a more efficient and cost-effective outcome (Burger, 2019). Another essential point, is the governmental commitment to transform the industry through the leveraging of digital technologies as highlighted above (Department for Digital, Culture, Media & Sport, 2017). The analysis of this big data that holds the value and the key to innovating the sector. The data collected from the creation of BIM models and IoT sensors on buildings will provide the foundations to subsequent applications as part of cyber physical systems in Construction 4.0. Artificial Intelligence (AI) and Machine Learning (ML) algorithms can be applied to the operation and maintenance of the building to make sure it runs as efficiently as possible. Similarly, the use of a Digital Twin of the built asset can be used to run models to analyse and optimise energy and heating prior to its application to the physical building. Ensuring it is not only running efficiently based on its operational environment but reducing the impact on the environment (Broo et al, 2021). Further examination of elements of these component parts of big data ideology will be undertaken below, but initial exploration as identified in the National Infrastructure Commission report (2017) highlights the underpinning philosophy is to use “data for the public good” (Howard, 2012, pp.1). Used primarily for urban planning and management, where large data sets are analysed to measure the impact of urban growth, or to improve the quality of life for residents (Smith, 2019).

Big Data refers to large, complex data sets from a variety of data sources. These data sets are often so large they cannot be handled through traditional data processing techniques (Oracle, no date). A major hinderance to moving to Level 3 is the unwillingness of companies to share data through the supply chain, thus leading to silos of information (HM Government, 2015). Furthermore, there is currently sparse research to date to ascertain value of big data usage relating to impact on the construction sector (Forcael, 2020).

Highlighted in both industry and academic research is the vast skills gap due to the complexity of skillset required to fully exploit the information available (Chevin, 2020), (Watson, 2020). Existing workforce needs to be reskilled and potentially the job specification and design of the future for traditional roles such as QS will need to be overhauled to meet the emerging requirements of digital transformation. Potentially new job roles will need to develop to accurately interpret and holistically apply the collation of Big Data (Kavuri, 2020).

The impact of existing Big-Tech on the market share is another concern. External to the AEC industry, one of the biggest threats is the diversification of Big Tech and start-up construction technology companies with a digital DNA at their core entering the market and disrupting it (PWC, 2020). By using information such as street layouts and weather patterns they can then use ML and computational design, to produce millions of planning concepts from the data. This convergence between the Tech and Built Environment (BE) is increasing with Tech companies now applying machine learning to the data in the BE (RICS, 2020). Application of Rogers' (1983) Diffusion of Innovation Model could support RLB in positioning itself against disruptors and competitors.

Critical to the application of Big Data, AI and ML are the ethical concerns, markedly taking a deontological (Ethics Unwrapped, no date) perspective already noted above by the National Infrastructure Commission, to use data for the public good (Howard, 2012). The main ethical issues apparent surround information security and consent, questions on privacy and privacy trade-offs, data-sharing, and anonymity (RICS, 2018). For example, due to the United Kingdom being more bound to ethical considerations surrounding data collection and its use, "Ethical drag" may restrict industry agility compared to other countries. GDPR, Freedom of Information Act and The Digital Economy Act legislate and regulate business behaviour in the UK, with sanctions including fines to a percentage of annual turnover and revocation of membership to professional bodies. However, much thought needs to be given at a leadership level on adversity of consequences arising from data use, both tangible and measurable and those more difficult to ascertain and evidence such as indirect discrimination.

Sustainability is a mega trend within construction, in the context of digitalisation and transformation this would look like strategic and considered use of digital technologies to reduce global emissions holistically across the supply chain, and throughout a building's life cycle.

Through efficiencies gained during the design and planning phase the use of digital technology such as BIM and analysis of big data there is an immediate reduction in waste. In the future, having a central repository of data through Level 3 BIM will allow greater collaboration and the sharing of best practice in green building design (Terol, 2020).

Using more accurate data can facilitate the construction of whole or component parts of buildings can practically eliminate on site waste with remaining waste products controlled and recycled, noise and debris on site furthermore can be extensively reduced by this process. Meticulous data programming enables increased efficiencies across the production cycle and prebuilt units can be flexibly and reflexively designed to utilise space within

delivery vehicles which in turn further reduces emissions (Countfire, no date). The accuracy of the data used for successful offsite construction depends upon the use of digital tools and frameworks such as BIM. The use of BIM enables early planning and testing of designs virtually and remotely which enables careful analysis on a range of traditional building issues such as safety and quality prior to the undertaking of any site work. Additionally, the data can be utilised to screen for incompatible or discordant physical components prior to manufacturing being given the green light (Kier Group, 2020). As with the limitations of every theme examined the confines for the success of this initiative rely heavily on the buy in and uptake of BIM and its related recommendations (The Quantity Surveyor, 2020). Green, goes further and posits that self-proclaimed construction leaders seek an improbable utopia where contractors turn miracle worker and transcend commercial logic to implement these changes (Green, 2016).

2.5 THEME 4 – DIGITAL SKILLS GAP

One of the major obstacles to digital transformation is a disparity between existing skills and future needs. RICS published a survey indicating required data skills currently mismatch the knowledge gained in training for roles (Longstaffe, 2020). It is evident that professional and technical qualification specifications for cost managers do not meet the current and future digital needs to allow for the full implementation of digital processes identified above. Riley (Watson, 2020), comments that both vocational and academic learning in the sector is insufficient to applying construction trends in practice as we move into the fourth industrial revolution. This supports the introduction in 2018 of data and new technologies competencies into RICS professional standards. Noted by Crowe (2020), 80% of UK business leaders believe digitally native staff to be crucial to post pandemic recovery, moreover 78% see this as a way to maximise leverage against the global market.

2020 *Construction Manager* BIM survey highlights over 50% respondents stating they rarely to never make use of BIM on their projects, noting paucity of digital skills as the reason. Additionally, the survey reports only 3% rapidly embracing digital technologies (Chevin, 2020).

Conspicuously, the cost of upskilling people is significant (Mdanayake and Çıdık, 2019), (Chevin, 2020). However, there is minimal research and evidence as to the investment required. There are several respectable sources indicating methods to encourage digital upskilling in the workplace mooting ideas such as Futurelearn, QA and Microsoft, but again there is no costing attached. RLB undertook a digital awakening initiative and tendered to leading UK online education platforms to deliver training and none offered any such product. Being more prescriptive in their training offer with digital apprenticeships that didn't meet the

business need. The offerings from these providers were generic digital as opposed to specific built-environment tech. RLB investigated the development of a bespoke “Digital Awakening” e-learning platform and received an indicative cost of £200k for its development and ongoing maintenance (Appendix A). This equated to a 2.86% investment of RLB’s net income (£200k/£7m).

2.6 CONCLUSION

The literature review reveals an emerging theme that industry and government recommendations, trends and component parts are all limited by the ability of people to recognise the value of data being collected, understand digital concepts, and apply technologies in a meaningful way. Digitalisation enables performance improvements that can be tied to productivity gains, but this relies on the presence of certain skills and knowledge, which require training. The construction industry is often reported as not optimally leveraging its productivity; however, it is widely accepted that implementing digital practices will redress this (Zhan et al., 2018). A thorough review of contemporaneous academic and industry literature highlights the existing digital skills gap across the industry as a whole, predicts that it will only widen and thus further impact the effectiveness of employees and overall outputs.

3 METHODOLOGY

3.1 METHODOLOGICAL INTRODUCTION

The research methodology rationalised the approach undertaken in this study to ensure the objectives are met methodically. A thorough review of the literature surrounding the impact of digitalisation and digitisation on cost managers in the construction industry by 2030 has identified a lacuna pertaining to the paucity of digital skills needed to successfully navigate the transformation of the industry.

The overall approach is an exploratory study, chosen as it is a valuable means to gain insight and ask open questions therefore enabling further discovery regarding a topic of insight. As this type of research is flexible it allowed for directional change based upon new insights gained, allowing the focus to become narrower through the progression of the research (Saunders et al, 2019).

3.2 RESEARCH PHILOSOPHY AND APPROACH

The research philosophy adopted for this project is epistemological with a subjectivism assumption. Epistemology is referred to as assumptions about knowledge, what constitutes acceptable, valid, and legitimate knowledge within a discipline (Bryman and Bell, 2011). The person interviewed, as a subject matter expert, thus legitimises the validity of the information received.

The subjectivism continua was used due to the reliance on primary data collected through a number of semi-structured interviews. A paradigm can be described as “a cluster of beliefs and dictates which for scientists in a particular discipline influence what should be studied, how research should be done, and how results should be interpreted” Kuhn (1970, cited in Bryman and Bell, 2011). Subjectivism assumes that those individuals directly involved within an organisation will understand the point of view of individuals directly involved in its activities, as an organisation has specifically constructed social norms and values (Bryman and Bell, 2011)

From an epistemological perspective the management philosophy undertaken for this research was Interpretivism. Interpretivism focusses on perceptions and interpretations to provide new understandings (Saunders et al, 2019), and placing less value on changing the world as opposed to understanding it (Fisher and Buglear, 2010).

The theory development approach used in this exploratory study is inductive, allowing the researcher to gain a better understanding of the nature of the research questions through

interviewing a sample of subject matter experts (SME's) in the construction industry. Inductive research theory allows for a theory to be developed from the outcome of specific and detailed findings (Fisher and Buglear, 2010) as opposed to deductive theory (Saunders et al, 2019). This is the most appropriate approach as the responses gathered from the interviews allow the creation of a theory and very little in-depth literature was available on digital skills gaps for cost managers specifically. As the purpose of this research is to inform the direction of travel for digital transformation within RLB, the information needed to be gathered from SME's in construction for relevance.

3.3 RESEARCH DESIGN

Qualitative research usually emphasises words rather than quantification in the collection and analysis of data (Bryman and Bell, 2011). This strategy lends itself to the previously discussed epistemological position of interpretivism as it requires researchers to interpret the meanings expressed about the phenomenon (Saunders et al, 2019), as well as the previously discussed inductive research theory.

Survey has been selected as the research strategy as it lends itself to exploratory research and the use of qualitative research strategies such as open-ended questioning. Survey research can be defined as "the collection of information from a sample of individuals through their responses to questions" (Check and Schutt, 2011, pp. 160).

Although survation is often associated with deductive research, for the purpose of this study inductive reasoning was used as it allows the development of theoretical explanations to social interactions in business and management, in a wide range of contexts (O'Gorman and MacIntosh, 2015). This will allow the forging of a new theory generated from data collected from the interviews.

Thematic analysis was used to analyse the responses from the interviews, offering a more flexible approach than other qualitative analysis methods and lends itself to the identification of emerging themes and gaps in the researcher's understanding. This method allowed the formulation of responses to assist in satisfying the research objectives of both risk assessment and recommendations to the business.

The time horizon of this research is cross-sectional, described as a study taken at a particular time, studying a particular phenomenon (Saunders et al, 2019). In this case a Survey strategy looking to identify factors relating to the impact of digitalisation and digitisation on the role of the cost managers.

3.4 DATA COLLECTION/ ANALYSIS

According to (Fisher, 2010), there are a number of different methods for data collection for primary research including focus groups, interviews, and questionnaires to name but a few. For this exploratory research project, interviews on a one-to-one basis were undertaken. Additionally, as noted by Fisher (2010) there are two main types of interview approaches: semi-structured and structured. In this case, data collection was undertaken using a semi-structured format. This allowed a pre-determined list of themes and key questions related to these themes to be used to guide the interviewee, allowing for responses to be probed for further explanation or to build on previous answers, thus gaining a further understanding (Saunders et al, 2019). The themes for the questions were derived from themes identified from the literature review.

The information used in the study is primary data collected from interviews. As noted by Hox and Boeije (2005), an advantage of using primary data over secondary data is the information can be focussed on the specific research problem through the tailoring of the interview questions. Additionally, a mono-method qualitative study was used as no quantitative data is used to warrant a mixed methods approach.

3.5 SAMPLE

A non-probability sampling approach was identified as the most appropriate as individuals are to be selected against non-random criteria. Primarily used in exploratory research, this method is used to develop an understanding of a small population. A limitation to this sample is that the conclusion may be deemed weaker than using a probability sample, this can be overcome through the selection of key people in the construction industry giving the results further credibility.

Three sampling techniques were used to identify interview candidates: Convenience sampling, Homogenous Purposive Sampling and Snowball sampling.

Firstly, convenience sampling was used to target senior leaders within the Cost Management service at RLB. These senior leaders are at the level of Partners and Managing Partners. Through engaging with these seniority levels of employee, a strategic viewpoint was given as well as wider industry knowledge of digital trends, and the impact these trends are making within the industry. The Partners (seen as the heads of the service) and Managing Partners (regional head) were all qualified practitioners in Quantity Surveying. This representative sample allowed for broader conclusions and provided quicker results compared to contacting the population of all QS's within RLB UK (~200 staff). Although this

could introduce sampling bias, this has tried to be mitigated through the definition of a target population and sampling frame.

The second sampling method of homogenous purposive sampling was used to interview parties that are members of key industry bodies or strategic entities within the construction industry, such as the [redacted] This allowed a broader viewpoint of the state of the industry to be established. Although these interviewees are not known to the researcher, they are known to senior leaders within RLB and were recommended as subject matter experts based on their current role or the organisation they work for.

Finally, snowball sampling occurred as some candidates were recommended based on being known within their own networks, and it was thought they would be interested in the project's findings.

A total of 18 candidates were selected – nine internal and nine externals. Even though six candidates didn't respond to interview requests, three new candidates were recommended bringing the total interview subjects to 15. This sample population was the minimum recommended amount for non-probability sampling according to Saunders (2012, p. 331). This target population provided enough of an insight and a high enough level of saturation for this particular study.

To preserve anonymity interview subjects were given a participant letter and their organisation information generalised. This maintained the level of gravitas attributed to the responses based on the persons level of seniority and industry (Table 1).

Table 3.1: Anonymised Interview Candidate Details

Candidate	Organisation	Position
Participant A	Professional Body	Director-level
Participant B	AEC – Professional Services	Digital Lead for Cost Management
Participant C	AEC – Professional Services	Head of London Cost Consultancy function
Participant D	Professional Body	Director of the Infrastructure Sector Professor
Participant E	Global AEC Company	Director level, leading innovation function
Participant F	Global AEC Company	Director level, focussed on consulting, strategy and innovation
Participant G	Online Building Wiki	Director
Participant H	AEC – Professional Services	Senior Cost Manager

Participant I	AEC – Professional Services Government Organisation	CXO level Involved with the National Digital Twin Programme
Participant J	AEC – Professional Services	CXO level Member of Construction Industry Council
Participant K	Global AEC Company	Vice President – Information Technology
Participant L	AEC Software Provider	Construction Solutions Executive, EMEA
Participant M	AEC – Professional Services	National Head of Cost Consultancy Global Board Member
Participant N	Global AEC Company	Group Chief Information Officer
Participant O	AEC Software Provider	Digital Transformation Lead

3.6 PROCEDURES

Data collection for both internal and external subjects was undertaken through synchronous electronic interview using Microsoft Teams. This approach was primarily selected due to the interview subjects were geographically dispersed around the UK and USA and allowed greater flexibility for undertaking the interviews. This meant the interview minimised the impact on both the subject and researchers time as there was no requirement of travelling to meet in person. As part of the invitation to the meeting the subject was given the option to attend via telephone. This removed the element of "Zoom fatigue" experienced by heavy users of video conferencing due to the Covid-19 pandemic.

When undertaking the interviews, the environment for the interviewer and interviewee was taken into account as these can impact the accuracy and quality of data gathered. Furthermore, the interviewee may be less willing to be as open due their surroundings. The interviewer undertook interviews from either a meeting room or their home office.

A number of morning and afternoon interview slots were offered to the interviewees allowing them to select the most appropriate time for them and reduce any impact on their working day. This was used to mitigate the impact of the interview on the subject, thus possibly reducing the quality of response.

Consideration was given to the GDPR act and its seven principles, in particular maintaining data integrity and security of the data collected. Interviewees were made aware of how the interview recordings were going to be stored and will be deleted once transcription has been completed.

All interviewees were given a Participant Information Sheet (Appendix B) and a Consent Form (Appendix C). The Participant Information Sheet gave them background to the research project, what will happen with any sensitive information, the themes of the questions as well as the anticipated duration of the interview. This gave the interviewee a broader awareness of what is required from them as part of this process and the option to turn down the request for interview if they do not feel they're suitable. Additionally, this could lead onto more suitable candidates being recommended through snowball sampling.

The open questions were produced based on key themes identified during the literature review. To maintain validity these questions were cross-referenced with the overall aims and objectives of the research study.

Prior to any interviews being undertaken the questions were piloted with a co-worker who has experience within this area of research. This provided feedback on the suitability of the questions to meet the aim and objectives of the research, as well as the running order of the questions. Additionally, the piloting of the questions allowed for any areas of bias to be identified and mitigated. The interview questions are available in Appendix D.

As the information will need to be transcribed and subsequently coded to identify themes all sessions were recorded through Team's built-in recording functionality, then auto transcribed through a third-party transcription product, Otter.AI.

Intelligent transcription was undertaken on the transcribed documents to eliminate irreverent details, repetitions, and any form of speech interruptions. This 'light editing' allowed the transcript to remain focussed on the responses. This was a more appropriate method than Edited Transcription and Verbatim Transcription. (Walker, 2020)

An example of a transcribed interview is available in Appendix E.

3.7 CODING

The transcribed interviews underwent two cycles of coding. A code is a label that assigns symbolic meaning to descriptive or inferential information during a study (Miles et al., 2014). Coding is seen as a data condensation task to retrieve the most significant information for the research study, identify recurring patterns to the cluster it together and high order themes derived.

The initial coding of the transcripts used a mixture of Descriptive coding and In Vivo Coding. This mixture of methods allowed a combination of labels based on key words and phrases identified in the transcript as well as the use of the interview subject's own words for codes.

Through this method of inductive coding the raw data controlled the creation of codes as opposed to the use of pre-existing codes (a priori) and trying to retrofit the data into codes.

The second cycle of coding allowed review of first cycle codes and the subsequent grouping of these codes into a number of meaningful Categories. Finally, these categories were then further grouped organised into six high order themes, as discussed in the Results/ Findings section.

Table 3.2: Summary of Research Methodology

Chosen Research Methodology						
Research Philosophy	**Type**	**Strategy**	**Time Horizon**	**Sampling**	**Data Collection**	**Analysis Method**
Interpretivism	Inductive	Survey	Cross-sectional	Non-probability (Convenience, Homogenous Purposive, Snowball)	Qualitative	Thematic

3.8 ETHICS AND LIMITATIONS

There were a number of limitations identified that should be addressed in future studies, firstly the short amount of available time to undertake the interviews meant the sample size was at the lower end of what it is recommended for a study of this type. However, this was mitigated by the seniority of the people interviewed and their position in their organisation or in the industry. Secondly, only nine interview subjects from RLB were approached, with some subjects from the same region. This could indicate some regional bias. This could be mitigated by inviting the lead cost management Partner from each of RLB UK's regions/ offices. Thirdly, more focus could have been on cost managers at RLB's global offices to gain a truly global perspective to the study, however, this was mitigated by a number of the interviewees being members of the Global Board members thus having an understanding of cost management globally. Similarly, one of the external parties interviewed holds a global role in a professional body therefore the narrowness of the results could be mitigated.

Additionally, only one professional body was included in the study, this could have been expanded to include other bodies such as the Chartered Institute of Building (CIOB) potentially providing a broader perspective based on responses to the questions and identified whether professional bodies are aligned.

To further broaden the viewpoint for the study the Government could have been approached for their viewpoint or engagement with Construction Leadership Council (CLC) where a number of senior industry and business leaders reside may have a given further depth to the study.

Additionally, the size of organisation the interview participants came from were global with multi-billion-dollar turnover and over 10,000 employees. To provide a different perspective, interviews with parties from different sizes of organisations may have given a different response and provided a broader industry viewpoint.

Finally, in some interviews there were instances of the interviewer having to provide guidance and examples of digital, data and technological concepts. This may have led some responses, but to mitigate this bias the interviewer gave broad responses to any examples and then asked further questions to qualify that the responder knew the subject and didn't just use the interviewer's response.

A number of ethical challenges were overcome as part of this study including maintaining the anonymity and confidentiality of interview subjects. To maintain anonymity the participant's name and organisation were generalised along with some specific job titles. Any responses that mentioned other interview subjects or confidential information were redacted. All responders were issued with a Participant Information Sheet (Appendix B) outlining how to raise any ethical concerns. The research study was put through Aston Universities Ethics committee and no issues were raised.

4 RESULTS/ FINDINGS

4.1 INTRODUCTION

The coding of responses from interviewees has identified a number of common themes and sub-themes, these are discussed briefly below along with pertinent quotes from interview subjects.

4.2 CHANGE MANAGEMENT

4.2.1 Change

As identified by a number of participants a paradigm shift within the industry is expected within 10 years or less. The majority of participants felt that this would allow the role to "...perform a more value driven role for the client..." (Participant L) and "not just look at the fiscal cost but also the carbon and sustainability cost" (Participant O), further adding value.

Resistance to change factored high in responses, with interviewees citing the “human element” (Participant O), “culture, behaviour and leadership” (Participant I) and the mindset of “this is how we’ve always done it” (Participant N).

Participants felt that as part of this change the work the QS undertakes will change with new tools improving efficiency, or the complete removal of low-level work such as take-offs or bills the production of bills of quantities to specialist teams or cheaper resource within the business.

Table 4.1: Results Relating to Change

Code	Frequency	Category	Theme
Digital Consultancy	1	Change	Change Management
Digital Foundations	1	Change	Change Management
Digital Income	1	Change	Change Management
Digital Partnerships	1	Change	Change Management
Digitalisation Priorities	1	Change	Change Management
Industry Timescale	1	Change	Change Management
Innovation	1	Change	Change Management
RLB Transformation	1	Change	Change Management
Timescale	1	Change	Change Management
Transformation Timescale	1	Change	Change Management
Change in Mindset	2	Change	Change Management
Opportunity	2	Change	Change Management
Transformative Change	2	Change	Change Management
Service Change	3	Change	Change Management
Slow Adoption	3	Change	Change Management
Change Timescale	4	Change	Change Management
Job Pressures	4	Change	Change Management
Digital Partnerships	5	Change	Change Management
Value Add	10	Change	Change Management
Low Value Work	12	Change	Change Management
Resistance to Change	18	Change	Change Management

4.3 DATA STRATEGY

4.3.1 Data/ Information

A common trend across responses was the importance of data, in particular with it being "sanitised, cleansed, reliable and structured", furthermore, one response highlighted that "I haven't seen how it take unstructured data" (Participant M).

Furthermore, a number of responses identified that without good data, "AI, Machine learning and big data is not possible" (Participant D) as well as insights later on (Participant K).

Data standards and establishing a common approach were noted by several participants. One participant said, "I think what's needed is some sort of data standards, internationally agreed, industry wide data standards" (Participant B).

Finally, the removal of data silos across the industry were identified by a number of participants as barriers that need to be broken down, with one participant commenting "But I still think that we've got a way to go there until we break down interoperability in the silos in the industry that prevent this information flowing freely between us all. But once we get there, I think that could be a radical transformation" (Participant I).

Table 4.2: Results Relating to Data/ Information

Code	Frequency	Category	Theme
Data is Foundational	1	Data/ Information	Data Strategy
Data Value	1	Data/ Information	Data Strategy
Global Data Standards	1	Data/ Information	Data Strategy
Risk of Unstructured Data	1	Data/ Information	Data Strategy
Single Data Environment	1	Data/ Information	Data Strategy
Value of Data	1	Data/ Information	Data Strategy
Data not Valued	2	Data/ Information	Data Strategy
Digital Best Practice	2	Data/ Information	Data Strategy
Structured Data	2	Data/ Information	Data Strategy
Data Standards	5	Data/ Information	Data Strategy
Data Silos	6	Data/ Information	Data Strategy
Data Structure	8	Data/ Information	Data Strategy
Data Quality	9	Data/ Information	Data Strategy
Data Sharing	10	Data/ Information	Data Strategy
Data Importance	16	Data/ Information	Data Strategy

4.4 DIGITAL SKILLS GAP

4.4.1 Skillset

A number of respondents highlighted a gap between the syllabus being taught in universities and the requirements for the industry, with the lack of teaching newer technologies and focussing on traditional techniques being an issue. One candidate mentioned “I think we are still teaching a curriculum for a QS that is a traditional way of how we've done things in the industry” (Participant J). Furthermore, the gap between what’s being taught and the requirements to become Chartered through RICS’ Assessment of Professional Competence (APC) was highlights as a problem “And what that means is that there's a bit of a gap quite often between what the university is teaching and what the RICS APC requires, and I think that's a problem” (Participant A).

Table 4.3: Results Relating to Skillset

Code	Frequency	Category	Theme
Board Upskilling	1	Skillset	Digital Skills Gap
Stakeholders	1	Skillset	Digital Skills Gap
Legacy Education Syllabus	5	Skillset	Digital Skills Gap
Academia behind Industry	6	Skillset	Digital Skills Gap

4.5 DIGITAL TRENDS

4.5.1 Analytics

A high frequency of responses indicated that the use of analytics against gathered data to gain insights and make predictions is important on multiple fronts including for clients to manage existing programmes of work, assisting the client to make decisions or for RLB to produce more accurate cost benchmarks.

Table 4.4: Results Relating to Analytics

Code	Frequency	Category	Theme
Data for Prediction	1	Analytics	Digital Trends
Dynamic Data Sets	1	Analytics	Digital Trends
Technology Impact	1	Analytics	Digital Trends
Industry Benefit	2	Analytics	Digital Trends
Insights	2	Analytics	Digital Trends
Data Predictions	3	Analytics	Digital Trends
Prediction	3	Analytics	Digital Trends

Project Benchmarking	3	Analytics	Digital Trends
Data Insights	5	Analytics	Digital Trends

4.5.2 Risk Management

A respondent highlighted that through the application of digital trends any issues to a projects supply chain can be quickly identified and appropriate steps undertaken, “For me, the big thing is, when you think about cost management was latency. The time you know, something happened, you know, from a design or a construction activity, there's going to cost impact, it was often days, if not weeks before you could actually understand the impact of it within there and the impact pathway” (Participant F). For a risk adverse profession such as quantity surveying, the management of risk for clients and through the use of analytics based on data gathered from IoT devices in buildings is seen to be of massive importance.

Table 4.5: Results Relating to Risk Management

Code	Frequency	Category	Theme
Risk	4	Risk Management	Digital Trends

4.5.3 Trends

A substantial number of interviewees all see the same trends such as AI, ML, IoT, Digital Twins and DfMA impacting the industry, with a further consensus that Data is key to all of these. Additionally, the majority of respondents agreed that interoperability between the products and platforms was extremely important, “The other thing I would say is connecting, making sure whatever is done that the platforms are open.” (Participant L). Responses from subjects indicated that the mandating and subsequent adoption of BIM over ten years ago has not be successful, with it not being utilised to its full potential to reap the benefits.

Table 4.6: Results Relating to Trends

Code	Frequency	Category	Theme
Automation	1	Trends	Digital Trends
Data	1	Trends	Digital Trends
DfMA	1	Trends	Digital Trends
Industrialised Construction	1	Trends	Digital Trends
ML	1	Trends	Digital Trends
National Data Lake	1	Trends	Digital Trends
Smart Cities	1	Trends	Digital Trends
Technology to Improve Efficiency	1	Trends	Digital Trends

Internet of Things	2	Trends	Digital Trends
Programme Schedule	2	Trends	Digital Trends
Technology Change	3	Trends	Digital Trends
Digital Twin	4	Trends	Digital Trends
Data Analytics	4	Trends	Digital Trends
AI	5	Trends	Digital Trends
BIM Adoption	5	Trends	Digital Trends
Tech Impact	5	Trends	Digital Trends
Technology Application	5	Trends	Digital Trends
Technology Solutions	6	Trends	Digital Trends
Data Driven Decisions	8	Trends	Digital Trends
Interoperability	10	Trends	Digital Trends
Horizon Scanning	15	Trends	Digital Trends

4.6 INDUSTRY

4.6.1 Clients

Based on a number of responses from interview subjects the client is seen as one of the key driving forces for innovation within the industry, with one response stating "…it's the clients that drive a lot of the industry, you know, without a doubt." with another commenting, "So it's kind of, what the clients asked for, I think drives a lot of the either it either drives a lot of the change, or it's a barrier to not changing because they're not asking for the right thing" (Participant I).

Table 4.7: Results Relating to Clients

Code	Frequency	Category	Theme
Client Pressures	1	Clients	Industry
Client Understanding	2	Clients	Industry
Client Driven	3	Clients	Industry
Client Objectives	4	Clients	Industry

4.6.2 Competitor Positioning

A number of sources identified that competitors are continually looking for ways to create new income streams. Whether this be through the vertical integration of the design team into the business, or through merger and acquisition of businesses "we're seeing some evidence in terms of rationalisation in the market between consultants, you know, Turner and Townsend joining CBRE, Davis Langdon already part of AECOM, EC Harris part of Arcadis" (Participant A).

Table 4.8: Results Relating to Competitor Positioning

Code	Frequency	Category	Theme
Competitor Change	1	Competitor Positioning	Industry
Competitor Rationalisation	1	Competitor Positioning	Industry
Competitors Position	1	Competitor Positioning	Industry
Industry Change Timescale	1	Competitor Positioning	Industry
Vertical Integration	1	Competitor Positioning	Industry
Competitor Service Transformation	5	Competitor Positioning	Industry

4.6.3 Industry Constraint

Interview candidates highlighted a variety of industry constraints including the size of the supply chain impacting the adoption of digital processes (Participant G), the industry being disjointed thus impacting how experts work connected (Participant N) and the industry working in a fragmented and siloed way (Participant A). Furthermore, the problems that are constraining the industry it is felt by one subject, could be overcome “But they are looking at it in different ways, which is quite, quite frustrating. The industry needs to come together a bit more” (Participant A).

A recurring response from candidates highlighted the protectionist attitude throughout the industry, “There's a lot of protectionism. Over the past 30 years, we've developed a real cloak and dagger system with regard to how the industry works, and how we protect our prices at the cost of all of this” (Participant O).

Finally, it was commented how the industry doesn’t make things happen by itself and it needs to be mandated to make changes, usually by the Government, for example through the Building Regulations and BIM Level 2 mandate (Participant G).

Table 4.9. Results Relating to Industry Constraints

Code	Frequency	Category	Theme
Complex Supply Chain	1	Industry Constraint	Industry
Disjointed	1	Industry Constraint	Industry
Industry Fragmented	1	Industry Constraint	Industry
Intellectual Property	1	Industry Constraint	Industry
Tier 1 Support	1	Industry Constraint	Industry
Wider Industry Awareness	1	Industry Constraint	Industry
Disparate Industry	2	Industry Constraint	Industry
Industry slow to adopt	2	Industry Constraint	Industry
Digitisation of Traditional Process	3	Industry Constraint	Industry

Industry Issue	4	Industry Constraint	Industry
Protectionist Attitude	7	Industry Constraint	Industry

4.6.4 Industry Drivers

A common response relating to this subtheme was the requirement around sustainability and carbon, “I think the cost management will be about the price, it will be about interpreting data to create value, but also, the cost manager (QS) will have a greater role in looking not just the fiscal cost, but the carbon cost and the sustainability cost” (Participant O). Another industry driver highlighted is the Golden Thread of Information coming from changes to the Building Safety regulations post the Grenfell tragedy. This will mean more data on building assets will have to be created and stored, building on data already stored in BIM models.

Table 3: Results Relating to Industry Drivers

Code	Frequency	Category	Theme
Climate Change	1	Industry Drivers	Industry
Government Driven	3	Industry Drivers	Industry
Sustainability	4	Industry Drivers	Industry
Carbon	5	Industry Drivers	Industry

4.6.5 New Entrants

Several participants noted how a number of tech companies are now moving into areas of the construction industry, for example Microsoft with their Digital Twin platform within their cloud (Microsoft Azure). Additionally, one participant commented how tech start-ups are getting investment from larger firms (Participant D).

Table 4.11: Results Relating to New Entrants

Code	Frequency	Category	Theme
Tech Company	5	New Entrants	Industry
Industry Change	13	New Entrants	Industry

4.6.6 RLB Positioning

It was noted by one participant that RLB won’t invent any new technologies but instead should “…make sure we're capable and able to adopt what is there to our advantage” (Participant H). Furthermore, collaborating within the industry and with RLB globally will be required to reach RLB’s digital transformation by 2030.

Table 4.12: Results Relating to RLB's Positioning

Code	Frequency	Category	Theme
Business Agility	1	RLB Positioning	Industry

RLB Global	1	RLB Positioning	Industry

4.7 WORKFORCE PLANNING

4.7.1 Skillset

A number of respondents highlighted how the role of the cost manager will change with the introduction of technology and digital processes, with an overall reduction in the core cost management skills. It was noted that there was a deficit in these skills for not only existing staff but also graduates and apprentices entering the profession.

Upskilling in data analytics and data interpretation it was felt would give the client the best value based on how the data would be used. Additionally, the requirement of the cost manager (QS) will be to "…not just look at the fiscal cost but also the carbon and sustainability cost" (Participant O). As well as technical skills, soft skills were mentioned as lacking by one participant.

The labour shortage within the industry was a recurring theme, in particular attracting people due to the perception of the industry, "…especially when other sectors pay more" (Participant M).

Table 4.13: Results Relating to Skillset

Code	Frequency	Category	Theme
Apprenticeships	1	Skillset	Workforce Planning
Data Science	1	Skillset	Workforce Planning
Digital Confidence	1	Skillset	Workforce Planning
Education	1	Skillset	Workforce Planning
Future Role	1	Skillset	Workforce Planning
Internal Digital Training	1	Skillset	Workforce Planning
Lifelong Learning	1	Skillset	Workforce Planning
Relevant Skillset	1	Skillset	Workforce Planning
Role Disappearance	1	Skillset	Workforce Planning
Role Opportunity	1	Skillset	Workforce Planning
Skill Nurturing	1	Skillset	Workforce Planning
Skill shortage	1	Skillset	Workforce Planning
Skills Shortage	1	Skillset	Workforce Planning
Skillset Bottleneck	1	Skillset	Workforce Planning
Staff Shortage	1	Skillset	Workforce Planning
Broad Skillset	2	Skillset	Workforce Planning

New Role	2	Skillset	Workforce Planning
Non-Construction Trained Personnel	2	Skillset	Workforce Planning
Reverse Mentoring	2	Skillset	Workforce Planning
Soft Skills	2	Skillset	Workforce Planning
Apprentices Skillset	3	Skillset	Workforce Planning
Digital Staff Retention	3	Skillset	Workforce Planning
Digital Toolset Exposure	3	Skillset	Workforce Planning
Digital Upskilling	3	Skillset	Workforce Planning
Skills gap	3	Skillset	Workforce Planning
Data Skillset	4	Skillset	Workforce Planning
Skills Deficit	4	Skillset	Workforce Planning
Skillset	4	Skillset	Workforce Planning
Skillset Change	4	Skillset	Workforce Planning
Existing Workforce Digital Skillset	5	Skillset	Workforce Planning
Interpretation	5	Skillset	Workforce Planning
Industry Perception	6	Skillset	Workforce Planning
Digital Skillset	10	Skillset	Workforce Planning
Graduate Skillset	10	Skillset	Workforce Planning

5 DISCUSSION

5.1 INTRODUCTION

The purpose of this research study was to investigate the impact of Digitisation and Digitalisation on Cost Management in the Construction Industry by 2030 and satisfy the objectives of horizon scanning innovations in digital technologies in relation to cost management, evaluating the impact of the key digital trends within the industry on the cost management profession, assessing areas of risk to the business and analysing how they can be mitigated, followed by making recommendations to capitalise on opportunities identified in the research.

5.2 HORIZON SCANNING INNOVATIONS IN DIGITAL TECHNOLOGIES IN RELATION TO COST MANAGEMENT

Neither the lit review nor the interview questions explicitly mention the term horizon scanning. To qualify the meaning of the term in the project objective; it was to assess which innovations in digital technologies in relation to cost management were being considered as key to the future of the role. In terms of synthesis of this in interview responses and literature reviewed prior to undertaking the research, there was a distinct correlation. However, perceptions were disparate as to predominancy of importance of emerging technology. AI appeared most frequently as a future disruptor. Followed by a recognition of the importance of analytics to projects…. Perhaps surprisingly, considering the weight given to BIM already in the literature review and industry itself was the infrequency of references to that in the future. This could be due to fact that it has now been 5 years since BIM Level 2 was mandated and it is now a standard part of the construction process and everyone has moved onto the next trend of analytics, bigger companies that are able to invest in the technology and training have done so, or it hasn't been implemented successfully in industry (Participant L, Participant E). As the data stored in a BIM model can be used in analytics this may explain why analytics is mentioned frequently.

Although Construction 4.0 was only explicitly stated a few times, the technologies and concepts underpinning this framework were regularly mentioned, for example BIM, automation, and AI (Buguin, 2013).

Participant F highlighted that data analytics is going to have the biggest impact on the industry. This view is prevalent across interview subjects, with a number of different drivers to use analytics, such as using the information to analyse different cost scenarios and

predict outcomes, predict carbon and energy requirements of a building, or predicting the impact of a change to a building programme and subsequently building in contingency to avoid or mitigate the impact. This view that the analysis of data is shared in the literature review by Broo et al (2021) as being key to innovation in the sector.

Conversely, Digital Twins and their use within the industry was highlighted by some other respondents as being the most important innovation on the horizon. Participant A identifies the use of digital twins as being essential to the industry. The exploratory use of this technology us already underway at some companies. For example, PCL, a large Canadian construction company has started to use digital twins on its construction sites and has partnered with Microsoft to provide their Digital Twin and IoT platform to assist.

However, as identified by Broo et al (2021), both analytics and digital twins are seen as key to adding value and driving innovation in the sector.

Interestingly the responses from the interviews suggest that there's a disconnect between what is seen as important by large scale multinationals with profits to the scale of billions of dollars and smaller, multi-million turnover companies.

The single respondent investigating Digital Twin from a practical point of view is Group CIO of a multi-billion-dollar revenue company. Similarly, respondents who highlighted their view of the importance of Digital Twins all held senior/strategic roles in professional bodies related to the industry, e.g., Participant A, it must be noted that Participant I's response could be expected to be such due to their involvement in the National Digital Twin programme.

Furthermore, this may indicate that the cost for implementation of the tech is prohibitive.

Interestingly, respondents working for a similar size enterprise highlighted that design for manufacture and etc were a priority for them, but this could be due to their having an existing Digital Twin service and are now operating beyond and looking to the next innovation on the horizon.

One interesting point raised by Participant D was the value/ importance of a common data environment (CDE), in essence a central repository or single source of information for the entire project accessible by all parties working on it. In light of the change to building safety regulations, and the golden thread of information and Hackitt report the importance of the CDE may be higher on business's priorities in twelve months' time. It may not be on everyone's radar however it was evident in the Lit review.

Additionally, Participants D, I and E, identify the need for interoperability around any system to ensure data can not only flow between software applications, but it can be analysed to

gain insight and not merely held within the authoring tool. Platform and application interoperability was mentioned regularly in interviews as key; however, it was not mentioned at all in the lit review. This could indicate one of two things: that there's an assumption that the data within these software applications or platforms will be accessible as standard, or the developer wishes to keep the data for their own gain, for example to sell on, or the offering of an API to access data is a payable extra. Furthermore, interoperability will go a long way towards removing silos of data which are potentially holding the industry back from achieving the full extent of collaborative working it could be capable of. This is reflected in the literature review by the 2016 Farmer Review (2016) and in HM Governments 2015 Level 3 Building Information Modelling – Strategic Plan (2015).

AI was a frequently mentioned emerging trend. The people mentioning however, were all RLB employees, potentially indicating they perceive it to be a critical innovation to apply to the organisation going forward (Klinc and Turk, 2019). Similarly to BIM, as an emergent trend deemed important to monitor, AI was mentioned by RLB respondents whereas the strategic take on this from Participant E mentioned that he does not consider the construction industry in a position to invest in AI yet. Again, in terms of horizon scanning does it best serve the interests of RLB to further consider the opinion of those who have a greater market share of the industry, and who operate at more of a cutting edge?

For AI or ML to provide valuable outputs the data being entered has to be correct. This was a consistent trend through all respondents. It emerged in the form of both explicit comments such as the importance of data being available for all and not siloed as previously mentioned, to the implicit understanding that none of this will be executed in a meaningful or accurate manner without sound strategy and management of the raw data and information. Commonly noted that an understanding of the importance of data was key to driving strategic change and underpins the changes to digitalisation that is needed to prevent the industry becoming outdated (RICS, 2020). As noted by Participant I, what is important is the valuing of, and managing of information to aid better decision making.

5.3 Evaluating the Impact of the Key Digital Trends Within the Industry on the Cost Management Profession

Both the literature and the interviews recognise the critical impact, both positive and negative around data usage, and that it requires a huge shift in understanding (RICS, 2019). As cited by Participant B, it currently, whilst an emerging theme, is not of interest to many QS's. Participant I was very clear that it is the interpretation of data gathered which informs better decision making, thus leading to creation of a competitive edge (Burger 2019). For RLB,

Participant J as a CDO acknowledges the business is relatively immature in its management of data, which Participant B identifies as a risk. Analysis of big data, is, as noted by Department for Business, Innovation and Skills (2013) is the key to unlocking the value of, and the innovation of, the sector. Participant M at RLB is keen to explore the gathering of structured data to predict costs. Participant L perceives that data will impact on everything.

To evaluate the impact of this Participant E suggests the QS will in future need to look at data holistically, and pivot from cost to data. Participant I expands upon this by discussing the value of capturing data early to use further down the line. RICS identify concerns as to the management of data, and ethical concerns and differences across nations, alongside consequences of data mismanagement. Participant J and Participant G identified the industry as a litigation environment therefore in current terms of industry reference changing roles, responsibilities and processes could be problematic.

Participant N mooted the potential of leveraging the data for monetization, in what is historically an industry with often small profit margins, by selling information as a revenue stream. This was backed up by respondents from Autodesk, in addition to making it systems interoperable. This would be a significant new method of working and allow for making money with very little effort from employees, in effect as Participant N suggest, making money when the business is asleep.

Whilst participants acknowledged the need for some form of data compliance and regulation, there is no mention of this in the literature. An oversight/limitation to the review as good use of data captured in raw form by QS's is, as denoted by Participant D, clearly foundational to being able to implement any of the discussed digital trends currently existing or emerging.

The literature identified sustainability as a mega trend within construction, in that digital transformation of existing processes will significantly reduce carbon emissions holistically, both throughout the life cycle of a building and across the supply chain. Participant O mooted the future need to consider the duality of not only fiscal cost as part of project delivery but additionally the sustainability cost. Participant D believes this to be a significant opportunity for the industry, and to look to Australian firms as a model of good practise in transforming cost consultancy services to incorporate carbon services, something he believes cost managers can be at the forefront of. With COP26 and UN Sustainable Development Goals we are moving towards parameters of compliance and sustainability targets. Is it appropriate business positioning to be ahead of the regulatory curve here? Participant C notes that RLB have to date already seem projects granted permission solely based on embodied carbon statements. Participant A cites the RICS perspective of the need for collaboration to ensure the success of sustainability targets, and that as a major

trend, the key issue holding the industry back, is, as mentioned in interoperability concerns, lack of communication and joined up thinking.

Participant F considers that client demand will be a huge driver as well as legislation. He considers it a certainty that clients will start to demand better data and better use of technology. Participant M, agrees, that if clients demand it, RLB will have to deliver, the concern there being that big clients do make that paradigm shift which leaves RLB under resourced and underprepared to deliver on their requirements. Conversely, Participant E notes that often architects claim to not be using technology such as BIM because clients haven't asked for it, but strongly believes that companies, as the professional and experts, should have the confidence to use the technology and convey the value of its use to the client. It should be skilled competence, using the best tools to provide the best service. RICS, with their Future of BIM report (2020), demonstrates an awareness of some of these issues by offering clear steppingstones to organisations around BIM integration.

From an impact point of view the industry has seen some vertical integration with some companies merging to provide the whole design lifecycle. This creates new income streams. Additionally, mergers and acquisitions are happening to the same ends (Participant A). Participant D identifies a range of big tech companies, such as Microsoft, (who are at the forefront of Digital Twins, and owner, client, occupiers of their real estate) who can develop platforms for intelligently managing their estate utilising digital trends. This is a significant departure from traditional ways of working and poses a threat to the share of the market available to traditional AEC companies. Furthermore, he identifies the venture capitalist angle these large tech companies are applying, by investing in tech start-ups. In particular he identifies Extracker and Briq as some of the most recent tech companies to receive funding. This extends the information gathered in the literature about diversification and convergence in the built environment and technology, with an increase in new tech entrants disrupting the industry by applying machine learning to built environment data and utilising as a revenue stream (RICS, 2020). A subsidiary of Alphabet (Google's parent company), Sidewalk Labs is a current example of this, similarly, Amazon has invested in a start-up called Plant PreFab specialising in prefabricated housing (ArchDaily, 2018). This is a substantial threat to the AEC industry.

A longstanding systemic dilemma within the industry is the size and complexity of the supply chain (Green, 2016) support the view of respondent Participant G, which Participant C expands upon to note the difficulty of being constrained by the lowest common denominator in that particular supply chain. The onboarding of digital trends may only seek to exacerbate these existing issues. For example, adopting BIM might be feasible/ viable within a larger

organisation, but the sole trader at the end of the supply chain may well not need or have the ability to facilitate this technology. To successfully implement changes then, he further notes the need for the tier 1 companies to support the shift from analogue by the smaller players. pbcToday (2018) proposes the instigation of a common direction of travel to support the implementation of this. Participant G, goes further and hypothesizes that there will not be a universal adoption unless it is mandated in legislation. Participant M describes his frustration at the slow adoption of digitalisation, and the errors that come with it of using tools which aren't fit for purpose. He believes the answer to this lies in universal investment in quality software.

This fragmentation is apparent in the data silos and protectionism which is endemic in the industry. However, this protectionism may arise from the previously mentioned litigation culture, and concerns around intellectual property. The roots of this lie in the small profit margins in the industry, each QS is judged by the fees that they earn for their employer, there is a perception that they cannot afford to lose the business advantage financially or intellectually (Participant D, G, and J). Conversely though, Participant A states the value and importance of small and medium sized organisations sharing knowledge as a tool for improvement and inspiration. This requires a stronger collaborative ethic and a creation of mutual trust.

5.4 Assess Areas of Risk to the Business and Identify how they can be Mitigated

Throughout the literature reviewed the most prevalent concern was the gap between the technology available and the capability of people to utilise it effectively (Watson, 2020 and Chevin, 2020). As Participant N succinctly outlined; he does not believe there are enough people yet that understand it. This presents an acute risk to the viability and profitability of the business. The skills gap can be broken down into three component parts: the legacy education syllabus, the disparity between academia and industry requirements, and the paucity of skill set of the existing workforce.

Participants E, M and J were clear in their responses that there is a substantial discrepancy between the academic delivery of QS degree qualifications and the practical workplace needs. It was of considerable concern that the curriculum was still centred around a traditional, and increasingly outdated approach to cost management. Participant A opined the difficulty in keeping up with industry, and cited a study undertaken at Northumbria University which mapped the professional competencies required by RICS for the QS to the curricula of accredited universities. Participant A feels to bridge the gap noted there needs a

much more prescriptive approach from the RICS, and greater collaborative working between the industry and CHOBE, the heads of the built environment in education. With that currently not in effect there is often a distinct gap between what is required and what is taught. Participant E concurs with further comments from Participant A around the means of ensuring the content taught maintains pace with technology.

Zhan et al (2018) concludes that despite broad acceptance that digital transformation will enhance productivity, it is oft reported as lacking optimal leveraging in this. Cost is a distinct barrier to upskilling (Chevin, 2020). However, as identified by Participant I, this is a companywide commitment beginning at board level to ensure capacity to drive digitalization.

This is a considerable challenge to workforce planning, but one which should be seen as a huge opportunity for incumbent workforce to embrace quickly emergent digital technologies (Participant F). Participant J perceives it needs a clear journey to take employees on but there are broad trends and themes that can be delivered to upskill. Participant A observes the professional shift to lifelong learning in the industry. A constant improvement through professional development. Participant B outlines the diverse skillset already necessary for the QS and highlights concerns around recruitment and retention risks regarding additional burdens of learning and applying digital technologies. Participant N considers it an internal professional development issue, with Participant M taking it further to reflect upon the QS upskilling in order to ensure that competitive advantage. All this sounds positive, if lacking in actual strategy to implement at present.

In terms of recruitment there is a seeming necessity for digital natives entering the industry within a relatively short time frame, but a risk that specific data scientists and those competent with data analytics and digital trends will be problematic to recruit, once again due to the relatively tight profit margins involved in the sector and higher pay in other sectors (Participant M, Participant J). There was a number of comments as to bridging the gap between knowledge and ability in new entrants and the solution appears to be in the better and greater use of the apprenticeship scheme, facilitating the training to degree level. (Participant O, Participant C).

Participant F, M, A and N spoke at length as to the role change requirements of the cost manager to align with a digital/digitised industry. As discussed in the literature by Longstaffe (2020). Some of the risks around workload may well be mitigated by the outsourcing of or ascribing low value work to AI/ ML. Participant D in particular extols the advantages of this. Participant H refers to it as more consultancy than churn, less work overall but higher end. The role will become more advisory and consultative. Transformational over transactional (Participant J and Participant L). Shifting to a value-add perspective and being seen as a

trusted advisor by the client, allows the focus to move away from just cost but to offer value through carbon management, sustainability and integrating wider related services. Removing churn work such as bills of quantities/ take offs, frees up time to work with the client on their drivers. Interpreting data for insights, by predictive analysis of existing data sets to provide cost benchmarking or programme management to mitigate risk, for which RLB have already begun to operate this model in Amsterdam (Participant C).

To facilitate this effectively necessitates careful management of change, however as Participant C states, in the aftermath of the immediacy of large-scale change in the pandemic, there is lesser fear on technology, as employees find themselves cognisant of the benefits of it and are more fully immersed in it than pre-2020. Participant I believes the industry wide changes will take decades, but concedes, as does Participant N, and Participant H that 10 years will see a reasonable transition. Participant C is keen to see a quick move and adoption of technologies used in Tier 1 companies for RLB. Participant M too would like to position RLB at the top table. Participant J once again highlights the concern around funding to enable this, as cited in the literature, RLB have a distinct advantage here with the ideation of their Digital Awakening e-learning platform, something which if used effectively could successfully support role change management. Participant E and Participant M believe change could happen more quickly, but Participant M is clear that the key is change management of people not systems. This, posits Participant B relies upon the business recognising the value in reskilling staff. Participant M identifies the drawback to this is time, against the existing model of practice of targets and low profit margins (Riley, in Watson 2020).

Participant L makes some insightful strategic observations around this, in that the start point is the business acknowledging the need for change and positioning itself where there is optimal buy-in at a level stakeholders feel comfortable with. A shift to risk taking as opposed to risk aversion is needed. As Participant N cites, allowing stakeholders to recognise the benefits of the whole shift to digitisation, but once again Participant O cautions that people are the weak link here.

5.5 Make Recommendations to Capitalise on Opportunities Identified in the Research

Recommendations pertaining to the mitigation of risk and recommendations to capitalise on the opportunities identified are covered in the Chapter 6.

6 CONCLUSION & RECOMMENDATIONS

This exploratory research study set out to investigate the impact of digitisation and digitalisation on cost management in the Construction industry by 2030. Through research of empirical evidence, triangulated with responses gathered from interviews with key industry figures six higher order themes were identified. However, of these six themes identified, there were three areas in particular which could be seen as the priorities: data value within the business, business positioning to meet its digital aspirations, and finally the gap in digital skills.

The research study and literature highlighted the collation and use of a range of data sources as the most critical emergent digital theme, but both RLB and external participants discussed concerns as to the present lack of interest in this shift by QS's. Additionally, participants frequently emphasised both the value and importance of data interpretation as foundational for a number of the technologies identified through horizon scanning, and to drive value for the client. The use of AI and analytics, all seen as important by RLB staff to remain competitive, rely on the collection of quality, structured data. This suggests that the implementation of a clear data strategy could support the business in better use of existing technology, ensuring there is a strategy in place to apply future technology and creating competitive advantage, better decision making to drive value for the client, and through the harnessing of data new income streams can be realised.

Numerous risks including reduced quality of outcome for the client, decrease in the speed of decision making to satisfy client requests and/ or accuracy of responses to clients' requests, significantly increase the likelihood of clients moving to competitors. Similarly, with data being the bedrock to so many construction technologies, poor foundations will have a knock-on effect to the usability and application of future and even existing products. Furthermore, poor understanding of data requirements can lead to non-compliance from both an internal and external, legislative perspective. Thus, risking reputational and financial cost.

An underlying theme identified was all participants realised the importance of data and that the quality and structure of this data is important to achieve the best outputs from its and to use it to its fullest extent. Participants also highlighted that the data is not fully appreciated by the parties creating the data and this mindset needs to change if we are to fully capitalise on this valuable resource. Unlocking the power of data could have a number of positive impacts on the business such as increased profit margins through the creation of new income streams or reduction of time spent on low-value work and improved reputation within the industry. Furthermore, it will assist in protecting the intellectual property (IP). Drawing

on the comment from Participant C, a roadmap for the digitalisation of core services may be beneficial to identify the digitalisation of core services and not just the digitisation of analogue processes (Participants I and E). This could lead to future innovations and facilitate services becoming digital to the core (Participant C). One method of mitigating risk to the business is the identification of a roadmap for the core business services including, but not exclusively cost managers which can feed into the overarching data strategy implementation. A roadmap could comprise future developments, service delivery and evolution of the service stream taking into account the micro and macro-economic environment.

Equally vital, the research has highlighted the importance of positioning the business to ensure the focus is correctly directed on its digital ambitions. Participants H and L indicated that the start point is the business positioning itself where there is optimal buy-in from stakeholders, at a level they're comfortable with, that what tech is out there is adopted to the advantage of the business. This was reiterated by Participant C wishing RLB adoption of technologies used by Tier 1 companies, participant M concurred. The main issue to come from this is funding to achieve noted Participant J. However, there was a clear division as to whether innovation should be client driven or part of an internal innovation roadmap presented to clients as a value-add proposition. These key insights lead to a conjecture that the business may benefit from taking a clear stance on positioning – does the Board wish RLB to be leaders or followers in terms of digital innovation? To make this decision a complete understanding of the whole picture of digitisation across the industry is necessary.

Market research of competitor's digital offerings would identify gaps in the market and where new digital services could be created. This could significantly support the determination of RLB's innovative position. Potentially leading to a business shift in moving low value work to cheaper parts of the organisation while new income streams are developed.

Participant J noted cost as a significant and potentially prohibitive factor in digital transformation. Chevin, similarly flags cost as a barrier however there is a lacuna regarding research and evidence of actual costs. The introduction of a clear data strategy to support the optimal utilisation of existing/emergent trends, and a defined market position is foundational for the third main theme identified by both the literature and the research to be addressed. The identified digital skills gap of both existing workforce, and future workforce is an obvious people issue, therefore could successfully be aligned to an emergent digital positioning and data strategy. Collaborating with the HR and L&D function from inception through to implementation. Failure to plug this gap could lead to plateauing or plummeting productivity. It may lead to an increase in turnover rates due to staff moving on to more

digitally enabled competitors as this is the direction of travel for the entire industry. Efficiencies of the technology will not be realised thus decreasing profitability as a people and time service taking longer to complete work will create narrower margins in an industry where this is already an issue. In turn this may have negative impacts on employees work life balance.

As part of the digital ambition, Participant D indicated that the sector does not have the sufficient skills for the fourth industrial revolution as cited by Riley in Watson (2020). Participant A considered that as technology moves quicker than academic syllabus can adjust, and Participant C mooted the better meeting of role requirements by apprentices as opposed to graduates. Perhaps a discourse needs to be forged at board level around this to meet future workforce requirements. With Crowe's (2020) study citing 80% of UK business leaders recognising digitally native staff are the future for recovery post pandemic, and 78% identifying this skill as a method of leveraging organisations against a global market, it could be suggested that RLB, as a global company maximises its potential through a multi-faceted strategy for digitally upskilling staff.

While this study focussed on the UK element of RLB, the wider RLB global practice business could be engaged with to drive this as a global initiative. This research study can be used as a springboard for further investigation into the other themes identified within the literature and by participants to further inform strategy decision making.

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APPENDICES

APPENDIX A – DIGITAL AWAKENING COSTS

APPENDIX D – INTERVIEW QUESTIONS

1. What do you perceive to be the digital and technological innovations (for example BIM Level 2, Modern Methods of Construction (MMS), ML, AI, Blockchain) that will have the greatest impact on cost management, and why?

2. What do you perceive to be the data innovations (Big Data, Analytics) that will have the greatest impact on cost management, and why?

3. What opportunities do you see for cost management as result of this transformation?

4. What barriers/ constraints do you see for cost management in the industry, and why?

5. With the AEC industry ranked so low in technological adoption, what do you see as a realistic timescale for transformative change?

6. What do you see as your organisation's digital transformation position by 2030?

7. Have you noticed any "early adopters/ first movers" within the industry, and if so what impact, if any, have you noticed? Either from a professional curiosity point of view, or in relation to impact on competitive advantage.

8. To what extent do you feel the role of the cost manager will change by 2030?

9. Do you believe that graduates entering the CM Profession currently have the required skillset to fulfil the needs of the construction industry or is there a deficit?

    a. Are Universities educating students with the right skills for the role?

10. Does the existing Cost Manager workforce have the required skillset to fulfil the needs of the construction industry by 2030?

    a. Do you foresee any specific skillsets for Cost Manager being developed to support the digitisation/ digitalisation? If so, what?

11. Are there any current Cost Management working practices you foresee disappearing by 2030, and why?