Asset management SMART technologies of the future

Dr Judith Callanan, Dr Rebecca Leshinsky and Dr Dulani Halvitigala

RMIT University, Melbourne

# Abstract

*New technology is rapidly changing best practice in asset and facility management. This paper examines the technologies that are available including the opportunities and challenges of implementing smart building technologies in buildings.*

*Case studies from three prominent smart buildings were analysed to identify best practice and then to apply lessons to commercial buildings in Australia. Interviews were carried out with commercial property managers to identify what technologies are currently being used and what challenges or barriers are faced in adopting new technologies within asset and facility management.*

*The implication of this research is that although the literature and case studies outline that new technologies exist and integration is easily applied, the interviews and analysis inform us that commercial building owners and managers are still hesitant in adopting smart technologies.*

This research was funded by RICS research trust.

Keywords: proptech, asset management, blockchain, operating costs, facility management

1. **INTRODUCTION**

Property has been one of the slower and more resistant industries to integrate new technologies, however, technological disruptors are now having a significant impact on the built environment. This is particularly evidenced by the growth in the popularity of smart buildings, with global corporations striving to be in such flagship buildings. This study examined the benefits and challenges offered by the uptake of new technologies, such as blockchain and AI, on asset, property, and facility management activities in Australian commercial buildings.

Existing technologies such as Building Management Systems (BMS) continue to be important technologies that can be expanded on to allow for further data to be collected and building efficiencies to be enhanced. The advancement of Building Information Management (BIM) that stores building drawings in 3D and operating information at the construction stage, can be run in conjunction with established BMS to provide a more efficient picture of the building infrastructure and operation. Software packages such as Aconex, that can collect and store the drawings and communications in the construction stage, can also be used for the management of communications relating to the ongoing operation of the building. With a combination of these technologies, the building information and lifecycle costings will allow property and facility management to be accurately recorded and a long-term asset management plan to be constructed.

Investment in data collection and storage has become an important component of efficient property asset and facility management. Effective data capture allows for better management and, therefore, a more informed decision-making process. Operating costs can be reduced by being able to accurately predict the requirements for cleaning and maintenance, which are major components of any building’s operating budget. Data collection is not constrained to predictions for operating expenses but can also be used for the increase in income generation. This can be achieved through more accurate targeting of advertising sales, maximising car parking rental, along with optimising the tenancy mix. It is important that the data is, therefore, collected in a manner that is appropriate for mining and that the raw data can be collected and stored with minimal loss. Data can also be used to enhance the tenant’s business and turnover rental, where information is collected that helps them understand customer purchasing behaviour. Data capture is a valuable asset in its own right and should be controlled by owners to allow for mining and, subsequently, more informed decision-making.

The use of robotics in cleaning and waste management, in conjunction with effective and meaningful collection of data can reduce operating expenses by more accurately predicting cleaning requirements and reducing waste handling and disposal costs.

Centralised services provide efficiencies in being able to benchmark expenses and asset lifecycles to ensure the costs are minimised through proactive management. Remote management of buildings and services is an important tool that can be used during national emergencies and has proven to be an important process after the COVID-19 pandemic. The management of buildings in remote locations can be improved by having a variety of technologies installed, such as BMS and CCTV systems, which enables the manager to be able to manage services while being offsite, thereby further cutting operational costs. Centralised services can also have the added benefit of allowing for the amalgamation of service contracts and minimising the requirement for maintenance to be carried out in an ad-hoc fashion.

Smart contracts and the use of blockchain technologies in property management are still in their infancy, however, there appears to be a willingness to learn more about the potential these technologies can add to transacting, record keeping, building providence, and how an integrated technological approach can enhance efficiencies and save on costs.

This paper examines how companies are making use of smart building technologies in their asset, property, and facility management activities in commercial buildings in Australia. It examines the benefits offered by those technologies, and the barriers and challenges of implementing smart technologies into commercial buildings. It also explores case study buildings of excellence to identify their best practices and what implementation lessons can be learnt for commercial buildings in Australia. By utilising case study analysis and interviews with asset and property managers, this study seeks to identify the implications of the use of smart building technologies in commercial buildings on their short-, medium- and long-term asset, property and facility management practices and strategies.

1. **LITERATURE REVIEW**

The existing literature has identified that the asset management industry is increasingly employing advanced technologies in their operations, and this is a rapidly growing service industry in its own right. The integration of the array of smart technologies enhances the quality of large volumes of data on assets in portfolios, supports consistent investment workflows and enables asset managers to make more informed investment decisions.

Pollock (2019) suggested that AI and blockchain technologies will help asset managers to develop more evolving strategies and generate better long-term returns than pre-packed strategies that are based on back-tested data or historical returns of investment options. Also, the management fee, which is a significant part of the operating costs of buildings, can be reduced significantly through the application of these technologies (Pollock 2019).

With digital technologies now an ordinary part of everybody’s daily life, workplaces too, have been progressing technologically, inducing the development of smart buildings (Lecomte 2019). Buckman et al. (2014, pp. 98-99) define smart buildings as “buildings which integrate and account for intelligence, enterprise, control, and materials and construction as an entire building system, with adaptability, not reactivity, at the core, in order to meet the drivers for building progression: energy and efficiency, longevity, and comfort and satisfaction”. Thus, the core of smart property consists of sustainability, innovative technology and user-centredness (Ullah et al., 2018), resulting in the optimisation of occupier comfort, productivity and satisfaction with the lowest possible energy consumption (Buckman et al. 2014). Advanced technologies in buildings help in the day-to-day building management activities such as tenant management, payment management and tools for landlords and tenants to communicate with facility management activities to ensure the efficiency and long-term sustainability of buildings (Baum 2017).

The existing literature has also identified significant operational improvements created by AI, big data, and machine learning technologies in several building-specific areas. These include energy efficiency/reduction and other environmental imperatives (Ameyaw and Chan 2014; Siu and Xiao 2016), internal environment improvements (Pitarma et al. 2016); workplace/worker productivity (Ekstrand and Damman 2016), performance measurement and management (Ling and Wong 2016; Douglas 2016), sustainable buildings (Georges et al. 2015), intelligent buildings (Arditi, Mangano & De Marco 2015), maintainability and durability of buildings (Enshassi and El Shorafa 2015), sourcing decisions (Perera et al. 2016) and advanced information and communication technologies such as digital tools, including building information modelling (Gheisari and Irizarry 2016).

As shown in Table 1, Novick et al. (2014) discussed how smart building technologies in buildings support asset managers in the decision-making process primarily by providing up-to-date and critical data on portfolios.

Table 1: Role of advanced technology within asset management

|  |  |
| --- | --- |
| **Asset management activity** | **What smart building technologies assist** |
| Portfolio management | * Provide real-time view of positions, exposures and risks * Support “what if” analysis of scenarios * Check recommended activities relative to client-defined portfolio compliance guidelines |
| Data control and operations | * Receive and load data from third parties including securities, benchmarks, ratings, prices * Capture organisation-specific data such as internal ratings and sectors * Confirm operations with counterparties * Take in information on corporate actions from data providers and process these changes |
| Portfolio administration | * Reconcile cash balances against the records * Calculate portfolio net asset values and performance * Produce performance attribution analysis to allow portfolio managers to understand the decisions driving portfolio returns |
| Risk management, compliance and oversight | * Oversee portfolio-level and firm-level risks and exposures * Ensure portfolio risks and returns are in line with organisation’s objectives * Monitor and manage compliance exceptions throughout the investment process |

As AI can conduct tasks in the same way as the human brain, including thought processes and the ability to progress (Rossini 2000), Borg (2018) argued that the use of AI in asset management could quickly deliver several efficiency gains. This comprises AI-supported access to complex data, AI contribution to the creation of proprietary sentiment analysis, AI alerts sent directly to portfolio managers about property-specific and market risks, and AI-assisted investment decisions. Moreover, AI based systems allow for intelligent matching and predictive analysis on property marketing websites (Ullah et al 2018). Rossini (2000) found AI expert systems to assist in phrasing and structuring property documents (e.g. leases), budgeting construction projects, elaborating reports and optimising communication between different stakeholders (e.g. clients, property and facility management) for efficient problem-solving. Sivaramakrishnan (2017) identified the following main areas in asset management where AI and machine learning technologies can be used effectively (see Table 2).

Table 2: Use of AI and machine learning in asset management. Source: Sivaramakrishnan, 2017

|  |  |
| --- | --- |
| **Main asset management area** | **Tasks** |
| Portfolio management and optimisation | * Portfolio construction and optimisation * Development of investment and risk strategies * Predictive forecasting of long-term price movements |
| Social media usage and analysis | * Market sentiment analyses, pattern charts for portfolios * Crowdsourcing ideas to bring analysts, investment managers, and asset managers together to share opinions and monitor trends |
| Event monitoring and timeline analysis | * Use of cutting-edge technologies to consolidate unstructured data and provide actionable insights by collating data from various portfolios. * The methodologies adopted include NLP, machine learning, and network analysis using sophisticated data visualisation tools |
| Customer interaction and services | * These services include statements of accounts and funds transfer in core banking, portfolio selection, risk return analysis and portfolio dashboard in the asset management space. |

Pollock (2019) suggested that AI and blockchain technologies will help asset managers to develop more evolving strategies and generate better long-term returns than pre-packed strategies that are based on back-tested data or historical returns of investment options. Also, the management fee, which is a significant part of operating costs of buildings, can be reduced significantly through the application of these technologies (Pollock 2019).

Big data analytics also offer advantages, in evaluation and speeding up processes (Ullah et al. 2018). With the aid of big data, property investors are empowered to predict supply and demand levels and determine price indices. Portfolio management services can benefit from big data when analysing diversified investment opportunities (Du et al. 2014). The provision of vast amount of data enables customers to be more confident in their decision-making which would eventually speed up transaction processes (Ullah et al. 2018).

AI and big data are being increasingly used to estimate the lifecycle costs of properties, which is a main function in asset and wealth management. By comparing building lifecycle costs using several cost estimation methods, Alqahtani and Whyte (2016) identified that Artificial Neural Network models (ANNs) supported by AI and big data were able to estimate the total running costs of their building samples with an average accuracy of 99 per cent. Günaydın and Doğan (2004) also examined cost estimation for residential buildings by ANNs and concluded that an ANN model can reduce the uncertainties in estimating costs associated with the structural system of a building. Kim et al. (2013) compared the performance of three methods (regression, Support Vector Machine and ANN) in estimating building construction costs and concluded that ANN models gave more accurate prediction results than the other two methods. Shehab and Farooq (2013) also identified that ANN models estimated the repair and replacement costs in their project sample and identified that such models save time, improve the accuracy of the estimates and prevent problems that are usually associated with inaccurate estimates. Such models would also assist users in comparing alternative projects and the proceed/do not proceed decision-making process. Metaxiotis and Psarras (2004) identified several benefits of neural networks (NNs) and genetic algorithms (GAs) in asset and wealth management including more accurate decision making, time gains, flexibility, improved quality of products and minimisations of human inconsistencies.

Building Management Systems (BMS), which consist of systems that are installed individually, controlling only separate tasks (e.g. lighting or elevators), have been with us for a long time. As these systems require the facility manager to aggregate such data, more advanced, partially integrated BMS that connect several automated activities (e.g. energy management systems) emerged. These are sufficient in supporting sustainability goals, such as green building certification, smart technology uses fully integrated, IoT enabled BMS to control the entire building technology without manual interaction. They consist of an underlying communication infrastructure that interconnects monitoring devices such as sensors, cameras, RFIDs (radio frequency identifications), meters or any kind of everyday appliances (e.g. doors, windows or lights), a cloud infrastructure, a data-mining analytical algorithm as well as user surfaces (Jia et al. 2019). The collaboration of these layers results in automated point decisions, allowing for informed, strategic, and fast decision-making as well as synchronised actions (Kejriwal & Mahajan 2016). The advantage of an integrated BMS lies in the interoperability between different systems, such as windows and air conditioning systems, even if they are manufactured by different companies (Jia et al. 2019). In contrast to previous application systems, IoT-enabled sensors are comparatively cheaper while providing more in-depth information (Veuger 2018).

The advancement of IoT technology influences the facility management of properties to a great extent, especially due to its globality, instant responsiveness, use of wireless technology, applicability for indoor and outdoor areas and remote tracking possibilities (Yang et al. 2013). This includes the ability of IoT devices to comprehend and respond to the needs of the buildings’ occupants and the property as a whole without requiring the local attendance of a facility manager (Wortmann & Flüchter 2015). IoT systems can, for instance, control heating, air conditioning and lighting, proactively engage in repair and maintenance, optimally allocate desks and rooms, enhance security systems, digitise logistics management, improve waste management as well as enable interaction with retail customers (Donovan et al. 2018). For example, lightbulbs equipped with IoT technology do not only provide light but can also register the presence of people and send information to the owner’s devices. Thus, these lights can fulfil the aim of a security system with minimal costs (Wortmann & Flüchter 2015).

Moreover, integrated systems collect a range of data that assists in performing facility and property management functions. For example, IoT systems can contribute to the understanding of utilisation patterns and provide knowledge with regards to the maintenance and refurbishment level, which can feed into life-cycle management and decision-making processes (Brous et al. 2019). In addition, they are able to assess a building’s operational efficiency, assist in budgeting and benchmarking as well as in the creation of financial reports (Ghasson 2006). The vast amount of data generated are not only useful on building level, but also on a portfolio or urban scale for descriptive, prescriptive as well as forecasting purposes (Kejriwal & Mahajan, 2016). In the retail sector, smart technology could be applied to register online sales, leading to the development of a more advanced turnover rent model (Smith & Savage 2016).

As part of an IoT-enabled BMS, sensors are mostly employed as monitoring devices in commercial property. Especially, Wireless Sensor Networks (WSN) are common in collecting data regarding indoor environmental quality (e.g. light, temperature), occupant behaviour and motion as well as energy usage. Therefore, sensors play a major role in maintenance and repair, being able to inform a human operator about the state of deterioration, faulty equipment and the need for replacement (Jia et al. 2019). Moreover, weather sensors can predict severe weather events and contribute to preparedness and resilience (Kejriwal & Mahajan 2016). Sensor-enabled bins can communicate their filling degree to enable efficient collection and minimise overflow (Adler 2015). In retail properties, sensors enable the vendor to identify consumer types, footpaths and their buying behaviour (Kejriwal & Mahajan 2016).

In addition, useful physical gadgets in facility and property management include robots and drones. While robots can assist in collecting and recycling waste, performing inspections and fulfilling maintenance and cleaning duties (Ullah et al. 2018), drones or Unmanned Aerial Vehicles (UAVs) are found beneficial to taking aerial photographs of properties and their surroundings in marketing activities (Newell 2017). Also, drones assist in mapping and surveying, making the process cheaper, quicker and safer (McNeil & Snow 2016).

Wearable technology, such as smartphones, Augmented Reality (AR) goggles, smart helmet visors, Global Positioning System (GPS) fitted safety vests, and smart watches, further assist in data collection in buildings (JLL 2017). With the aid of wearable devices, occupants, facility managers and builders are linked to the property, receiving the possibility to interact with the smart building technology to adjust heating or cooling, but also to obtain immediate information with regards to maintenance and safety issues that can also be passed on to the tenants and/or owner. Through the increased interaction with the building, consumers’ affection for the building might increase (Ullah et al. 2018). In retail properties, smartphone apps enable customer interaction, guiding them through the shop, while pointing at special promotions and assisting them in finding car parks (Kejriwal & Mahajan 2016).

1. **METHODS AND DATA**

Using case study analysis and interviews with leading Australian asset and property professionals, to the research strives to identify the implications of the use of advanced technologies in commercial buildings with respect to asset, property and facility management practices and strategies.

Although the literature review has shown that a variety of technologies exist and possibilities for integration seem endless, commercial building owners and managers are hesitant in adopting smart technologies. Three buildings were interrogated as case studies: The EDGE - Amsterdam, International Towers - Sydney and Olderfleet – Melbourne. These are three very different commercial developments.

**The EDGE** was purpose built as a state-of-the-art smart building. The EDGE was completed in 2014, titled as “the most sustainable, smartest office building in the entire world” (EDGE 2020b) (See image 1). The building is equipped with an extensive, ethernet-based IoT-system, controlling building functions and components such as lighting, HVAC, security, coffee machines, lockers, gym equipment and meeting rooms (Bakker 2020; Davies 2019). In total, 28,000 sensors collect information about the building operations and its interactions with the employees. The LED lighting system consists of 6,000 luminaires equipped with IP addresses and with smart sensors, allowing to monitor the indoor environmental air quality as well as occupant movement (Davies 2019). Moreover, the automated ceiling system allows employees to individually adjust the temperature and lighting levels at their workplaces (Bakker 2020).

Image 1: The Edge building, Amsterdam, Netherlands



LaRosa (2016)

**International Towers** is part of a twenty-two-hectare development site – at Barangaroo, and these towers were built as three sustainable commercial office buildings. (image 2)

Image 2: International Towers, Barangaroo, Sydney, Australia



Council on Tall Buildings and Urban Habitat (2020)

The complex is equipped with an Open Building System Integration (OBSI) based on iviva software that communicates through an Integrated Communications Network (ICN) (Operational Intelligence 2020; TetraTech 2018). The software enables the connection of various systems from different vendors, such as HVAC, lighting, CCTV, hydraulics, access controls, meters, and elevators, across the three towers (Operational Intelligence 2020). In total, over 1,000,000 real-time I/O points allow the building management team to monitor building systems, observe CCTV recordings, administer alarms, manage property access, and control comfort levels (Peterson 2018).

**Olderfleet** consists of a contemporary 38 storey office tower located next to a heritage-listed building which was completed in 2020 (Mirvac Group 2020a) (See image 3).

Image 3: The Olderfleet Building, Melbourne, Australia



Mirvac (2020a)

The building is equipped with a fibre-optic infrastructure that can be connected to offsite data centres as well as risers that are suited towards accommodating technological advances. Moreover, the building features an extensive data infrastructure, consisting of smart building sensors and an operating platform to control temperature, lighting, and CO2 levels of individual workspaces. Energy and water usage, renewable energy production and waste management are constantly monitored to ensure efficient operations. In addition, the entire building features a wireless overlay and a vast number of telecommunication carriers to guarantee mobility and workplace flexibility (Mirvac Group 2020c). Furthermore, the property is equipped with Bluetooth digital access and automated systems for lockers, car parks and bike storage (Mirvac Group 2020b).

These case studies have helped to identify those advanced technologies in best practice buildings and examined how such technologies can be encouraged in commercial buildings in Australia, considering the barriers and challenges of adopting these technologies. This framework was then applied to formulate interview questions for the second methodology in the study, which comprised three one-to-one in-depth interviews with high-level property professionals. Interview participants were selected from a wide range of property companies who develop, invest in, manage and occupy smart and technology-efficient commercial buildings. Participants were employed by an Australian Real Estate Investment Trust, a Global commercial and residential property consultancy and management company, and an international infrastructure and property development company. The interviews lasted for over an hour each, and the questions were designed to elicit an in-depth understanding of these expert perceptions and experiences with the use of advanced technologies in their asset, property and facility management related operations and decision making.

1. **RESULTS**

The core messages emerging from the interviews can be summarised under three headings: new technologies; financial benefits; and risks or challenges.

**4.1 New technologies**

The appetite for new technologies is driven first and foremost by building owners and owner-occupied design-built buildings, rather than property or facility managers. Further, for advanced technologies to be adopted, there is the need for an executive team and board who are supportive of new technologies and innovation for their buildings. Some property firms have invested in dedicated teams with skill sets beyond asset, property, and facility management who work on developing integrated, centralised and automated systems. This allows professionals with specialist knowledge to develop new ideas and technologies for the large commercial developments they manage.

The areas impacted by new technologies include car parking, building security, cleaning, waste management, supply of utilities, HVAC, and centralised control rooms to manage multiple retail centres via remote management. These new technologies have created new systems such as the storage and on-sell of electricity off the grid via blockchain technologies, and the use of automated robotic rubbish bin collection.

All interviewees indicated that there has been a slow start to the introduction of smart building technologies. This has been caused predominantly by a lack of knowledge, rather than a reluctance of what smart building technologies are available and therefore the advantages to introducing new initiatives. The goals of building owners and their appetite to introduce smart building technologies were a major factor regarding which market participants are actively pursuing this advancement. Interviewee 1 emphasised “*the importance to have an executive team and Board that are supportive of smart building technologies and innovation as there are costs incurred that may take a reasonable amount of payback time*”.  According to this interviewee, their company took a very focused approach by employing a property specialist to lead a team to investigate developing systems that are integrated, centralised, and automated. The team included specialists from different backgrounds, not just property or facility management, such as electrical, security, cleaning services, and IT.

**4.2 Financial benefits**

The benefits of a centralised BMS system and comprehensive data collection are found in efficiencies in relation to facility maintenance. This can be achieved by being able to plan maintenance, have a long term asset management plan, and also grouping maintenance jobs together to avoid duplication of costs.  Benchmarking of data is commonly carried out against prior year energy consumption and reviewing operational expenditure. Benchmarking is also made against Property Council of Australia benchmark data to check whether buildings are performing within typical ranges (interviewee 1 and 2).  Proactive use of the system to determine better consumption or replacement of plant assets is carried out.  In addition, *“consultants and maintenance personnel use benchmarking for checking that everything is running in accordance with requirements”* (interviewee 2).

When dealing with service providers, who are generally paid on an hourly basis or on a contract to maintain / service the building, *“it can be difficult to get them to be proactive in instigating efficiencies that will reduce their time required”* (interviewee 1). Therefore, it is left to building managers to be proactive in this area, to drive the costs of operational expenses down.

A significant cost has always been the cleaning of the building.  Avidbots are automated cleaning machines that are used at night to clean retail centres and commercial common areas. As interviewee 1 suggested *“they are now being used extensively to clean floors in centres and create savings on labour costs. Initially there was a lot of resistance as companies that provide the physical labour pushed back on them and did not want to use them, with the expectation being that it would reduce the labour costs”* (interviewee 1). The Avidbot can map out the building to efficiently carry out the cleaning and at a time when there will be a lower volume of pedestrian use.

Financial savings are obtained through management being able to reduce the operating costs of the common areas.  In accordance with the Australian Property Council 2019 benchmarking data, building operating expenses (OPEX) have increased by around 5% per year, which can mainly be attributed to increased labour costs. By consolidating suppliers and using procurement efficiencies through smart technologies this cost can be minimised.  Interviewee 1 noted that through efficiencies and implementing automation technology, their company has been able to keep OPEX down to a zero increase per year.  This is a positive outcome as labour and material costs and have been increasing over the same five year timeframe.

Building efficiencies can also be gained through sustainability initiatives.  When sustainability features such as solar panels and recycling water were encouraged by the Australian government, electricity and waste disposal were relatively cheap compared to current prices.  Interviewee 1 discussed how these two areas have gone up substantially over recent years which has led to their focus in reducing these costs. An integrated energy strategy is required which involves management techniques in being more efficient in the operation of building, for example monitoring temperatures, opening buildings later and closing earlier to reduce energy costs, more efficient services such as lifts, HVAC, escalators.

Solar energy is a technology that has been strongly promoted through subsidies in Australian commercial property operations in the last twenty years.  In most commercial buildings in Australia, solar systems have been installed as cost reducing measures, rather than to provide a financial return.  One initiative that can be used to achieve cost savings is to charge the solar storage battery during off-peak times (lower cost of energy) and then energy is consumed at peak time period, to provide a lower cost to the end user.   This reduces energy consumption from the grid, where it is purchased at a higher cost.  Balancing between solar energy, buying off the grid and spot pricing (energy is purchased at the price set at that point in time) is an important management tool for property managers.

This was emphasised by interviewee 1: *“reduction in energy costs has become a focus of the management of the facilities. This has led to a management requirement that, at the time of introducing new systems that impact assets, a plan is required to show the cost benefit, including how the ongoing maintenance is going to be managed and cost savings made”*. This initiative means that all staff are focusing on how cost savings can be made with new proposals, without reducing the service or quality of the operation.

Centralised Building Management Systems (BMS) and comprehensive data collection allows for improved planning of maintenance and long-term asset management, which assists in reducing the duplication of costs. Property companies that engage in comprehensive data collection collate valuable raw data, which is an asset that can be used or on-sold for data mining. The collection of big data, and its subsequent analysis, inform retailers of customer habits, and this influences subsequent retail location and advertising decisions. Data capture allows for better management decision-making, more efficient adjustment of maintenance and cleaning times, and improvement in tenant mix optimisation. New technologies for tagging and barcoding of assets, and data storage, allow better control over the location, maintenance and life cycle of assets, and there are further opportunities with blockchain technologies for creating electricity on-selling to tenants.

**4.3 Risks or challenges**

Prior to adopting new technologies, building owners and property managers must ascertain how such technologies can provide efficiencies and financial benefits for their sites. Any uptake of these advanced technologies will be dependent on the owner’s appetite for new technologies as well as the level of knowledge of the person or company managing the asset. The existing literature, the case study analysis, and findings from the interviews in this study suggest a slow uptake of advanced technologies such as blockchain. Further, there is little knowledge of what opportunities are on offer by making use of blockchain technologies.

Data capture is a useful and highly lucrative asset. At stake is who will own and control the data, particularly when there is a third party managing and collecting and storing this data. There continue to be limits to what knowledge this information provides. Pedestrian traffic, for instance, counted in common areas or retail centres, is still limited in what the information means as it does not explain why people are not visiting the site. There is still great scope to ensure data accuracy, which is important for decision-making and occupational health and safety and maintenance concerns.

The core messages from the case studies are Purpose-built smart buildings were built to incorporate the latest technologies to be sustainable and smart developments. The uptake of advanced technologies and continued interest in these is more likely if the owner (or REIT) is directly involved and has their own in-house property asset management team. Technologies such as smart lighting, sanitary facilities, filling coffee machines and printers, waste, and traffic occupancy can help plan for demand in the cafeteria, energy usage, space utilisation, and smart flexible workstations. Comfort and well-being (WELL certification) are also important and impact on employee productivity. By the same token, privacy continues to be a concern of employee users who opt out of tracking devices and apps to book rooms etc.

The case study literature suggests that data ownership is uncertain at building completion. This will be a future concern for owners and occupiers, particularly as there is real value in this data, which can assist with asset and facility management. Current smart buildings are intent on energy saving, especially with lighting and amenities. The case study literature suggests smart technologies are more commonplace in Europe and North America. In Australia, there has been a pick-up in WELL certification for the built environment.

1. **CONCLUSION**

The study has highlighted some important findings for the call for, an introduction of advanced technologies into commercial buildings. From the study, we conclude that BMS, CCTV and other traditional technologies continue to be important core technologies, which have scope to be upgraded and adapted into new technologies, especially as they relate to remote management.

Data capture allows for better management and decision-making, as well as more efficient adjustment of maintenance and cleaning times, security controls, maximisation of advertising, and the improvement in tenant mix optimisation. This also offers opportunities to reconsider the importance of sound data collection, which can feed into remote management practices, particularly as the ability to have remote management has been so important during national emergencies, as was evidenced during the recent bushfires.

As data capture is highly valuable, it should be controlled by owners to allow for mining and subsequent decision-making for retail location, advertising, car park operations, security, maintenance, and cleaning. Further, the findings show that advanced technologies allow for improved efficiencies in waste management and energy usage.

Introducing new technologies and upgrading existing ones does allow for efficiencies to be gained by amalgamating service contracts, centralising services, use of robotics for cleaning and waste management and extensive, accurate data collection. To achieve such outcomes, there is a need to create quality teams for the implementation of advanced technologies in building management, with a mix of staff skills to capitalise on specialist knowledge.

Whilst there are opportunities for advanced technology uptake, there is still significant scope to consider the use of smart contracts and blockchain technologies in new areas such as the on-selling electricity off the grid and record keeping. Such change, however, was not at the forefront of the thinking of most of the managers interviewed.

The study highlighted numerous opportunities and challenges for the introduction and use of advanced technologies in buildings. The social isolation that resulted during the COVID-19 pandemic has fast-tracked the requirement and appetite for new technologies to enable remote building management and offering opportunities to work with these advanced technologies on a pathway forward to enhance efficiencies whilst at the same time collect and use data in an ethical manner which is respectful of privacy and aligns with sound corporate social responsibility.

**REFERENCES**

Adler, L 2015, The urban Internet of Things: Surveying innovations across city systems, Ash Center for Democratic Governance and Innovation, Harvard Kennedy School, viewed 28 August 2020, <https://datasmart.ash.harvard.edu/news/article/the-urban-internet-of-things-727>

Alqahtani, A & Whyte, A 2016, ‘Evaluation of non-cost factors affecting the life cycle cost: an exploratory study’, Journal of Engineering, Design and Technology, vol. 14, no. 4, pp. 818-834.

Ameyaw, E E & Chan, A P C 2014, ‘Evaluating key risk factors for PPP water projects in Ghana: a Delphi study’, Journal of Facilities Management, vol. 13, no. 2, pp. 133-155.

Arditi, D, Mangano, G & De Marco, A 2015, 'Assessing the smartness of buildings', Facilities, vol. 33, no. 9/10, pp. 553-572.

Bakker, R 2020, Smart buildings: Technology and the design of the built environment, RIBA Publications, Milton, UK, viewed 1 September 2020, <<http://ebookcentral.proquest.com/lib/rmit/detail.action?docID=6032932>>

Baum, A 2017, PropTech 3.0: The Future of Real Estate, Said Business School, University of Oxford, Oxford.

Borg, P 2018, Will data + AI = enhanced alpha, viewed 9 September 2020, <https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/emeia-financial-services/ey-will-data-ai-enhanced-alpha.pdf>

Brous, P, Janssen, M & Herder, P 2019, 'Internet of Things adoption for reconfiguring decision-making processes in asset management', Business Process Management Journal, vol. 25, no. 3, pp. 495-511.

Buckman, A H, Mayfield, M & Stephen, B M B 2014, 'What is a smart building?', Smart and Sustainable Built Environment, vol. 3, no. 2, pp. 92-109.

### Callanan J. Leshinsky, R. Halvitigala, D. ‘Blockchain and Smart technologies in asset, property, and facility management’. Royal Institute of Chartered Surveyors (RICS)

Council on Tall Buildings and Urban Habitat 2020, The Skyscraper Centre, photograph, viewed 14 September 2020, <<http://www.skyscrapercenter.com/building/international-towers-sydney-tower-1/13280>>

Davies, G 2019, 'Digital transformation and the future office', in N Gillen (ed.), Future office: Next-generation workplace design, RIBA Publications, Milton, UK, viewed 1 September 2020, <http://ebookcentral.proquest.com/lib/rmit/detail.action?docID=5806928>

Donovan, N, Gray, A & Shaw, R 2018, The Internet of Things and the property sector, DLA Piper, viewed 28 August 2020, <https://www.dlapiper.com/en/australia/insights/publications/2018/03/the-internet-of-things-and-the-real-estate-sector/>

Douglas, M U 2016, ‘Finding the niche towards performance excellence: a study of facilities management firms in Malaysia’, Journal of Facilities Management, vol. 14, no. 4, pp. 330-349

Du, D, Li, A & Zhang, L 2014, 'Survey on the applications of big data in Chinese property enterprise', Procedia Computer Science, vol. 30, pp. 24-33.

Ekstrand, M & Damman S 2016, ‘Front and backstage in the workplace – an explorative case study on activity based working and employee perceptions of control over work-related demands’, Journal of Facilities Management, vol. 14, no. 2, pp. 188-202.

Enshassi, A A & El Shorafa, F 2015, ‘Key performance indicators for the maintenance of public hospitals buildings in the Gaza Strip’, Facilities, vol. 33, no. 3/4, pp. 206-228

Georges, L, Haase, M, Wiberg, A H, Kristjansdottir, T & Risholt, B 2015, ‘Life cycle emissions analysis of two nZEB concepts’, Building Research and Information, vol. 43, no. 1, pp. 82-93.

Ghasson, S 2006, 'A critical review of the impact of embedded smart sensors on productivity in the workplace', Facilities, vol. 24, no. 13/14, pp. 538-549.

Gheisari, M & Irizarry J 2016, ‘Investigating human and technological requirements for successful implementation of a BIM-based mobile augmented reality environment in facility management practices’, Facilities, vol. 34, no. 1/2, pp. 69-84

Gunaydin, H & Dogan, S 2004, “A neural network approach for early cost estimation of structural systems of building”, International Journal of Project Management, vol. 22, pp. 595-602.

Jia, M, Komeily, A, Wang, Y & Srinivasan, R S 2019, 'Adopting Internet of Things for the development of smart buildings: A review of enabling technologies and applications', Automation in Construction, vol. 101, pp. 111-126.

JLL 2017, Wearable tech: The new tool for the modern construction workforce, viewed 27 August 2020, <https://www.jll.com.mx/en/trends-and-insights/workplace/wearable-tech-the-new-tool-for-the-modern-construction-workforce>

Kejriwal, S & Mahajan, S 2016, Smart buildings: How IoT technology aims to add value for property companies, Deloitte, viewed 31 August 2020, <https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/real-estate/deloitte-nl-fsi-real-estate-smart-buildings-how-iot-technology-aims-to-add-value-for-real-estate-companies.pdf> .

Kim, G, Shin, J, Kim, S & Shin, Y 2013, ‘Comparison of School Building Construction Costs Estimation Methods Using Regression Analysis, Neural Network, and Support Vector Machine’, Journal of Building Construction and Planning Research, vol.1, pp. 1-7.

Lecomte, P 2019, 'What is smart? A property introduction to cities and buildings in the digital era', Journal of General Management, vol. 44, no. 3, pp. 128-137.

Mirvac 2019, Mirvac celebrates topping out at Olderfleet, viewed 10 September 2020, <https://www.mirvac.com/about/news-and-media/mirvac-celebrates-topping-out-at-olderfleet>.

Mirvac Group 2020a, Olderfleet: Where heritage meets contemporary surrounds, viewed 10 September 2020, <https://olderfleet.mirvac.com/>

Mirvac Group 2020b, Six star facilities, viewed 10 September 2020, <https://olderfleet.mirvac.com/experience/end-of-trip>Ling, F Y Y & Wong, M G 2016, ‘Redesigning facility management operatives’ jobs to increase work outcomes’, Journal of Facilities Management, vol.14, no. 1, pp. 50-68.

McNeil, B & Snow, C 2016, The truth about drones in mapping and surveying, Skylogic Research, viewed 26 August 2020, <https://droneanalyst.com/wp-content/uploads/2016/12/TheTruthAboutDrones_mapping-1.pdf> .

Newell, C 2017, 'The use of 'drones' in marketing a property for sale', REIQ Journal, vol. Jun 2017, pp. 35-37.

Novick, B, Goldstein, R, Nair, S & Tevet, S, 2014, The role of technology within asset management

Operational Intelligence 2020, Barangaroo JLL Contractor Awards, viewed 10 September 2020, <https://www.operationalintelligence.com.au/operational-intelligence-team-awarded-by-barangaroo-jll-contractors/>.

Perera, B A K S, Ahamed, M H S, Rameezdeen, R, Chileshe, N & Hosseini, M R 2016, ‘Provision of facilities management services in Sri Lankan commercial organisations: is in-house involvement necessary?’, Facilities, vol. 34, no. 7/8, pp. 394-412.

Peterson, J 2018, International Towers Sydney, Barangaroo South: A New Benchmark for Smart Buildings, Realcomm, viewed 17 August 2020, <https://www.realcomm.com/news/879/1/international-towers-sydney-barangaroo-south-a-new-benchmark-for-smart-buildings>.

Pitarma, R, Lourenço, M & Ramos, J 2016, ‘Improving occupational health by modelling indoor pollutant distribution’, Facilities, vol. 34, no. 5/6, pp. 289-301

Pollock, D 2019, How is Blockchain and Artificial Intelligence changing the face of asset management?, viewed 9 September 2020, <https://www.forbes.com/sites/darrynpollock/2019/01/22/how-is-blockchain-and-artificial-intelligence-changing-the-face-of-asset-management/#2653b81b6d79>

Rossini, P 2000, 'Using expert systems and artificial intelligence for property forecasting', in Proceedings of the Sixth Annual Pacific-Rim Property Society Conference, Sydney, Australia, 23–27 January.

Shehab, T & Farooq, M (2013), "Neural network cost estimating model for utility rehabilitation projects", Engineering, Construction and Architectural Management, vol. 20, no. 2, pp. 118-126.

Siu, K W M & Xiao, J X 2016, ‘Design and management of recycling facilities for household and community recycling participation’, Facilities, vol. 34, no. 5/6, pp. 350-374

Sivaramakrishnan, A 2017, Decision analytics using Artificial Intelligence and Machine Learning: An asset management perspective, viewed 9 September 2020, <https://www.tcs.com/content/dam/tcs/pdf/Industries/Banking%20and%20Financial%20Services/analytics-artificial-intelligence-machine-learning-0817-1.pdf>

Smith, M & Savage, D 2016, 'The new real', Land Journal, pp. 6-8.

TetraTech 2018, International Towers Sydney, Barangaroo South, viewed 17 August 2020, <https://www.tetratech.com/en/projects/international-towers-sydney-barangaroo-south>.

Ullah, F, Sepasgozar, S & Wang, C 2018, 'A systematic review of smart property technology: Drivers of, and barriers to, the use of digital disruptive technologies and online platforms', Sustainability, vol. 10, no. 3142, pp. 1-44.

Veuger, J 2018, 'Trust in a viable property economy with disruption and blockchain', Facilities, vol. 36, no. 1/2, pp. 103-120.

Wortmann, F & Flüchter, K 2015, 'Internet of Things', Business & information systems engineering, vol. 57, no. 3, pp. 221-224.

Yang, L, Yang, S H & Plotnick, L 2013, 'How the Internet of Things technology enhances emergency response operations', Technological Forecasting and Social Change, vol. 80, no. 9, pp. 1854-1867.