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THE INTERNET OF THINGS IN CONSTRUCTION

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WHAT IS THE INTERNET OF THINGS?

Self-diagnosis, self-configuration and self-optimisation. In a nut-shell this is what the Internet of Things (**IoT**) can bring to construction.

In simple terms, IoT is a network of embedded sensors, meters, appliances and devices capable of sending and receiving data about changes to their current physical state and surrounding environment over the internet.

The sensors that have been put in everyday items such as mobile phones have now reached the construction industry. The various objects, equipment and components used in the sector can have telematics sensors installed to monitor operating conditions. The conditions can then be tracked remotely and reported back through specialist software.

When on site, IoT can help answer questions such as the cost of unscheduled downtime when a machine breaks, why a particular machine operator uses higher fuel levels than average and when replacements should be made for particular parts or components at current usage levels.

IoT has also facilitated the rise of 'smart' or 'digital' buildings. Using these interconnected technologies help to monitor a building's performance, flag up its inefficiencies and make automatic adjustments. However, HVAC, lighting and fire safety systems already have sensors that can read inputs and adjust outputs. So why do we need IoT when most buildings already have their own internal networks?

IoT makes the running of a building a data-driven process. The technology can pull data from sensors to help facilities managers form useful operational insights. Currently, many existing building management systems (**BMS**) do not fully utilise the vast amount of operating data being generated. IoT can help identify operational issues more easily as most building operators do not have the time to analyse historical trend data in order to identify these operational problems. Having a BMS that can integrate and automate data analysis that results in simple and actionable insight frees up time for facilities managers.

What Can IoT Offer Construction?

IoT technology has the scope to benefit projects on site during the construction phase as well as in completed buildings from a facilities management perspective. Some of the capabilities are summarised below.

1) Enables 'Just-In-Time' Provision

- When units of supply are labelled with radio frequency identification (**RFID**) tags, a system on site can count them. Therefore, when the count drops below a given level, the system can trigger a request from a central system to order more. Idle time goes down, and projects have a better chance of being completed on time. Costs are also contained because the construction company does not need to order in significantly more supplies than it is likely to use at any one time. Instead, just-in-time provision becomes possible automatically.

2) Tracks Tools and Equipment

- Allows you to track what tools are already on site, reducing time spent looking for lost or misplaced items and eliminating unnecessary expenditure on replacements.

- GPS data can monitor vehicle fleet locations and allow landscaping equipment to be precisely positioned.

- By monitoring the performance data of machinery and vehicles, the ability to maintain and repair them is enhanced. Preventative maintenance is cost-saving as it far more expensive to fix components after they break. Unexpected equipment failure can also lead to downtime, extending the project timeframe. Sensors tracking indicators such as excessive vibration and temperature help identify the best time to service equipment by sending warnings to connected devices so that operators can fix the underlying issue before further damage is caused. IoT can therefore lengthen the life of the equipment and improve its resale value.

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The Internet of Things in Construction
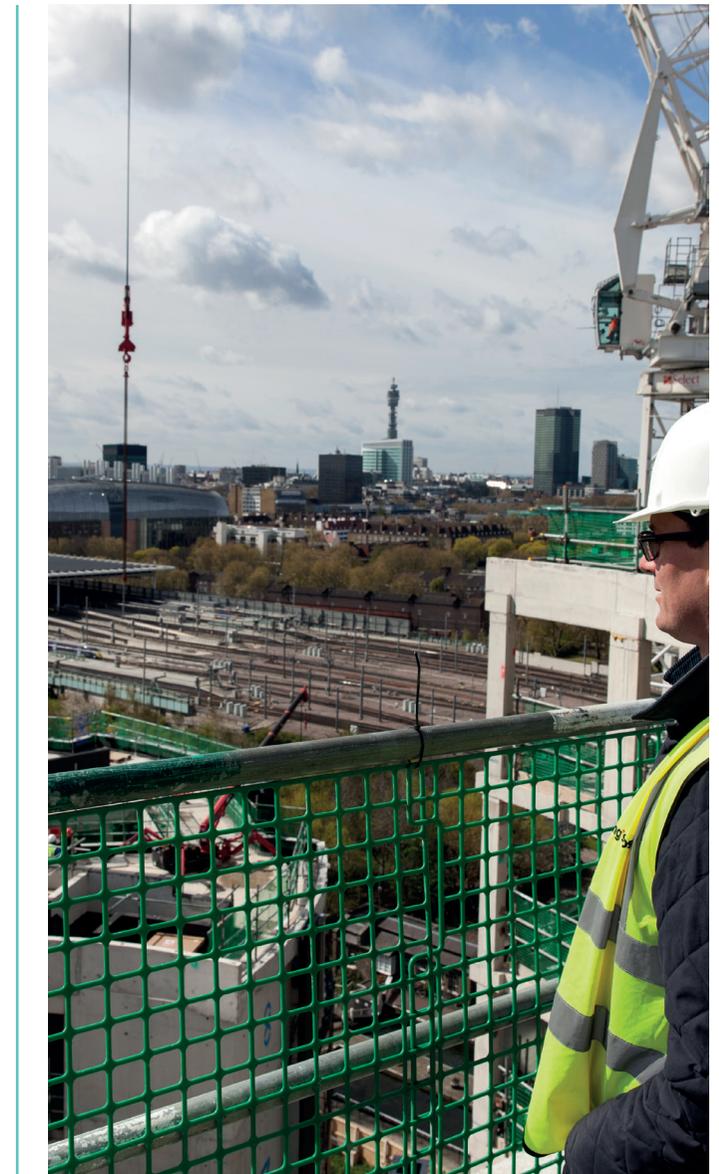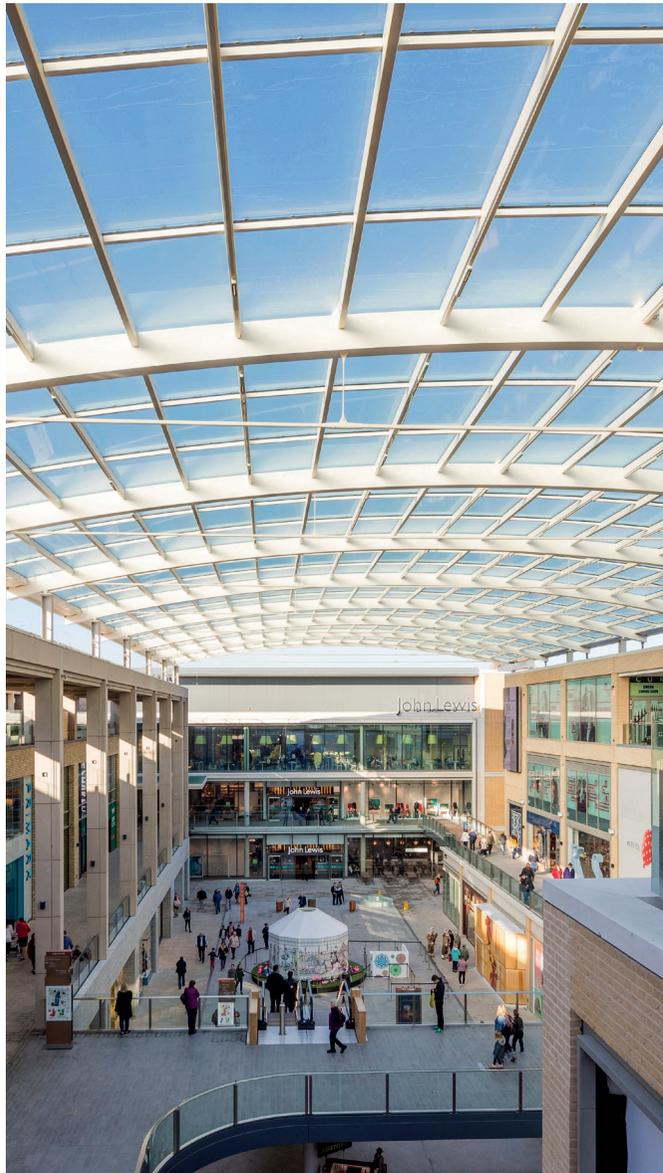
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3) Remote Usage and Activity Monitoring

- IoT technology can monitor the health and alertness of workers as well as their working conditions in order to help prevent fatigue and reduce the risk of possible accidents.

- Wearables that track employee location can also increase productivity. Knowing who is on site and where tasks can be more easily and efficiently co-ordinated can reduce idle time. Also, monitoring activity of workers allows employers to easily link employee performance with a task or process on site.

- Additionally, an office with IoT can potentially reduce employee absenteeism and sickness.

4) Power/Fuel Saving

- Fuel can account for a large proportion of a machine's operating expenses and ultimately the total projects cost. If a machine is consuming fuel whilst running idle or an operator is using substantially more fuel than average, IoT devices can identify this so that corrective action can be taken.

- Sensor data can also be used to adjust after-hours lighting levels on site for energy savings.

- In a 2011 report, Accenture found that smart solutions that can continuously monitor and commission a building's maintenance whenever the analytics engine detects a fault or irregularity, can reduce total HVAC and lighting costs in buildings by 10-30%. Furthermore, Accenture observed that deployment of smart technology in buildings usually pays back within 18-24 months[1]. More recently Bettina Tratz-Ryan, Research Vice President at Gartner Inc., said:

"Especially in large sites, such as industrial zones, office parks, shopping malls, airports, or seaports, IoT can help reduce the cost of energy, spatial management, and building maintenance by up to 30 percent." [2]

5) Augmented Reality (AR)

- AR can be integrated into equipment visors and vehicle windshields to provide a virtual map. Environmental and contextual data collected from IoT sensors can be displayed in real-time and overlaid onto a real-world view of the job to be done or journey to be made.

[1] Energy-Smart Buildings – Demonstrating how information technology can cut energy use and costs for real estate portfolios (Accenture)
[2] Gartner, Inc Press Release, "Gartner Says Smart Cities Will Use 1.6 Billion Connected Things in 2016," December 7, 2015

6) Sensors Placed in Completed Buildings and Structures

- The inputs that sensors can monitor are endless (eg humidity, CO2, light, water flow, noise levels and acoustics). Built-in analytics can look for unexpected or anomalous patterns in the data and make automatic corrective adjustments in real-time.

- Sensors can also send back information about the way materials are affected by time/climate etc. This can help improve the efficiency of the building as well as generating insight on how structures behave in earthquakes for example, or how a bridge bends under the weight of passing traffic. Models can then be built for predictive analytics.

- Data from sensors such as those that measure indoor air quality (**IAQ**) can be presented on mobile applications. By mapping the physical conditions for wider public consumption, building occupants can assess wellness performance. This type of data will become increasingly important as it will determine where people will want to live and work, and how much they are willing to pay.
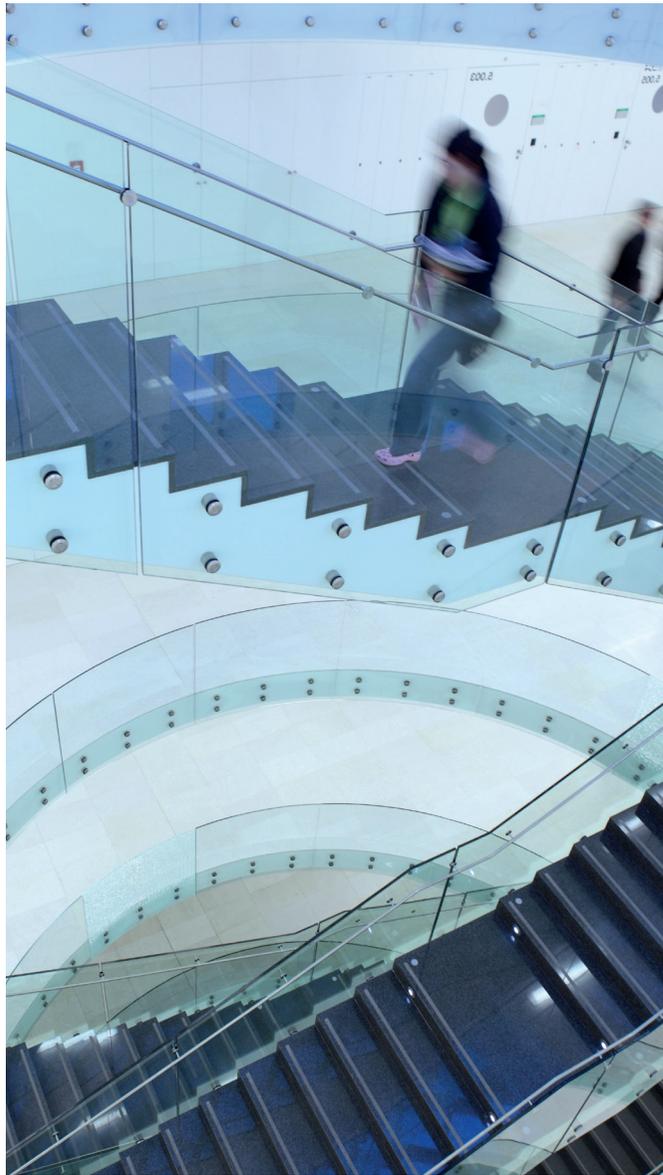
IoT for Smart Buildings

Smart buildings use small sensors and interconnected technologies to communicate information to facility managers and building users. In fact, smart buildings go a step further than this. Smart buildings now interact in real-time using the information recorded by the sensors to adjust the performance of the building eg fresh air flow can be adjusted based on occupancy levels.

Smart buildings also provide predictive capability. For example, data on external weather conditions can be used to predict energy use during peak periods, allowing the building's automated systems to adjust and optimise their performance. However, improved building performance isn't the only way in which an IoT-enabled BMS can create value. Smartphones can also be used to track the behaviour and preferences of building users so that building owners can build more sophisticated services and enhance user experience. End user behavioural data from other IoT-enabled buildings can also be used at the design and development stage of a building's construction so that it can be adapted for consumption and usage patterns.

While smart buildings provide improved sustainability, security and performance, there are some concerns about the technology. The most important concern being about life-cycle costs. From planning to completion most construction projects for new buildings take around three to five years. However, in a rapidly changing technological environment, new technologies can have a significantly shorter life-cycle with its capacity doubling every 18 months. Therefore, systems specified in the planning process can be two or more generations old by the time occupants move in. Whilst retrofitting can be done there are environmental and cost implications of doing so.

Google's New London HQ (Kings Cross)

G&T is providing Cost Consultancy and Contract Administration services at Google's new London headquarters. Once complete, the building will be one of the most advanced smart buildings in the world. As Google is the end user occupier, they have been able to push the boundaries more than usual so that smart capabilities are fully integrated.

The appointment of a Master Systems Integrator (**MSI**) at the earliest possible stage was a key focus on this project. This is not unique to this building as it has occurred on other end user Smart buildings but it is an additional role over and above that which is usually found on a "typical" office build and the scope in this instance far exceeds what has been done before. This is in respect of the quantity of data that is going into the BIM model detailing the properties of each of the building components and the level of testing of those components in advance of construction in a "laboratory" or workshop environment to ensure compatibility.

In order to mitigate the issue of technical obsolescence as far as possible, the MSI contractor on this project is engaging with all trades and their respective suppliers to ensure that the ability to accommodate future advances in technology currently in development is built in. A key part of this has been to ensure that all components are open source, allowing them to communicate with each other and the integrated building control system (**BCS**) which can then offer data up to Google's network.

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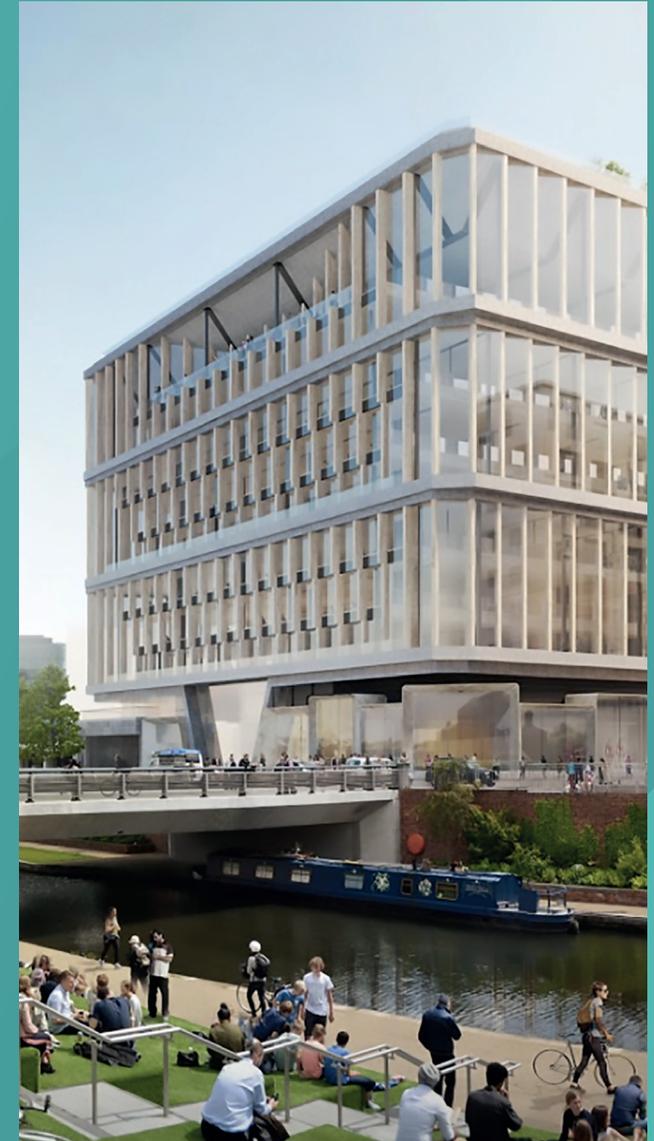
IoT Adoption Barriers

Construction worksites have been slow to adopt IoT. McKinsey argues that this is because of the fragmented nature of the industry with contractors and smaller subcontractors dividing the work[3]. There are also a wide variety of sites making it more complicated to standardise the implementation of IoT. Smaller sites with fewer workers will have less of a need for complex sensors and software as operations can be efficiently managed by the foreman. The advantages and added value that IoT can bring to larger-scale projects are much more obvious.

Any project considering the use of IoT will have to consider the expected completion time. Shorter construction projects need more immediate productivity gains than longer projects, which can justify smaller productivity gains. Smaller productivity gains over a longer project period aggregate into more substantial time/cost-savings.

On a more practical level, if an IOT device loses connectivity it cannot send data in real time, losing the ability to track and provide insights into preventative maintenance.

Also, whilst sensors can help benchmark preferred levels, they cannot always replace the benefits of physical observation. In completed buildings, poorly implemented technologies can disempower occupants, taking away their control of their environment and frustrating their user experience. With the volume and detail of data coming from IoT technology, there is risk that the data may be managed and processed incorrectly leading to inefficiencies.

Smart functionality in buildings also raises data privacy concerns. Smart buildings offer visitor arrival notification functionality that picks up the mobile phone signal of guests entering the building, notifying their hosts of their arrival. Many are anxious about their movements being tracked so instead the focus needs to be about monitoring space in order to ease concerns and improve perception of the technology.

Closely related to this is the issue of security. The BMS can be particularly vulnerable to hackers intent on taking control of and manipulating systems by using malware. For example, it is possible for bad actors to disable cooling systems in data centres and server rooms which can lead to downtime or even loss of sensitive data. Cyber security needs to be given as much consideration as the structural integrity of a building, and therefore employing an IoT security firm that understands the potential threats to the BMS is a necessary cost.

During the building stage, it may be that only the largest construction companies will have the ability to implement IoT operations. More likely is that mass adoption of IoT will come from equipment suppliers competing to supply the most efficient equipment to construction firms.

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3 McKinsey&Company – The Internet of Things: Mapping the Value Beyond the Hype (June 2015)

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Costing 'Smart'

Generally, by introducing smart technology early on in the development process, we would expect the following to have an impact on a shell and core/CAT A office building:

SMART Tech: *The cost premium is the increased number of BMS sensor points, but primarily the additional software programming required. Dependant on the level of spec, we would expect this to increase the BMS package by 15-30%.*

Enhanced Energy Management System (EMS): *The energy saving strategies and billing requirements necessitate a more complicated infrastructure to be installed with increased software engineering time required. We would anticipate an additional 20-40% over and above a standard EMS installation.*

The degree or level to which a building is classified as 'smart' will impact cost. A building with limited smart hardware will obviously cost less than a fully smart hardware option with IoT sensors and a full suite of functionality. A fully smart enabled building with a software platform that offers an end user app will push costs higher still.

IoT sensors are not expensive, but their co-ordinated deployment requires more expensive software specialists and applications. To avoid higher initial costs, building owners may choose to opt for a halfway house smart fit-out that allows tenants to add smart software functionality further down the line at their own expense. This effectively futureproofs the building so that it is at least capable of supporting a smart fit-out.

Regardless of the level of smart being used, owners of smart buildings expect the return on their investment to come from higher rents and lower vacancy rates. A recent report from Morgan Stanley claims that buildings optimised for occupants can command 3% more rent and gain a 10% increase in equity value.[4]

Value can also be created through other revenue sources. For example, offering tenants and other interested parties 'analytics-as-a-service' where data can be purchased. For example, data on tenants/occupiers movements could be sold to urban planners or advertisers.

[4] Morgan Stanley - Bricks, Mortar and Carbon: How Sustainable Buildings Drive Real Estate Value (page 8)

Procurement

The costs associated with adding smart technology to the BMS and EMS are continuously moving due to increasing levels of demand, more efficient infrastructure and constantly evolving hardware. We understand that a framework type methodology is being adopted by developers with work shared across their portfolios enabling project proficiency to be easily transitioned on to the next development.

Retrofitting or extending the functionality of old BMS systems used to present a challenge. Historically, it had been difficult to get legacy systems to integrate and communicate with newer building systems as IoT data had become increasingly unstructured and many legacy systems could only handle structured data. However, the latest generation of BMS remove the interoperability barrier between different building systems. Open-source protocols now allow different systems to communicate with each other, becoming integrated by API software.

Arkessa, an IoT managed connectivity service provider, notes that cellular-enabled sensors that can connect wirelessly to the internet without needing to build new physical infrastructure or create a new private network, can simplify the deployment of IoT devices to existing (non-smart) buildings. Russell Carr, Head of Operations at Arkessa, says that:

"Connecting construction equipment or smart building devices via a cellular network means that developers can get their IoT projects up and running straight away, without needing to install costly fixed cables or relying on local networks managed by third-party IT departments."

While retrofitting smart technology to existing buildings is generally less efficient and more disruptive than including it in new builds, the benefits can be nearly identical.

5 Wellington Place   © Harry Archer

CONCLUSION

The cost premium for incorporating initiatives such as smart building technology and an enhanced EMS are obviously extremely difficult to accurately quantify. Some of our peers are stating £1.50/sq ft (GIA) uplifts to provide some of these ingenuities. However the extra over cost is reliant on the level of specification adopted across individual projects. The premium paid is relative to the majority of these initiatives being in their infancy. Cost and risk will always be higher if stepping into the unknown. As the technology progresses, it will be able to be built into design and buildability strategies earlier on in the development process.

Smart buildings incorporating effective technologies have not been operational for long enough to undertake a realistic life cycle appraisal so the long-term cost benefits are still relatively unknown.

As a whole, the construction industry is still very much in the research phase of its IoT journey. With comparatively low rates of productivity on an output per worker basis, the industry is arguably ripe for disruption. Construction sites and buildings generate vast amounts of valuable data that presently goes uncaptured. Measuring and processing this data can improve efficiency, potentially reduce costs and improve safety and security. It can also help facilities managers and construction workers move from a reactive to a pro-active approach to maintaining building systems and managing construction sites.