The Evolution of Smart Buildings: An Industrial Perspective of the Development of Smart Buildings in the 2010s

Marson, M.

The Evolution of Smart Buildings

An Industrial Perspective of the Development of Smart Buildings in the 2010s

EUR ING **Matthew Marson** MEng (Hons) CEng IntPE(UK) FIMechE FRSA

A thesis submitted in partial fulfilment of the requirements of the University of Westminster for the degree of Doctor of Philosophy

February 2022

Abstract

Over the course of the 2010s, specialist research bodies have failed to provide a holistic view of the changes in the prominent reason (as driven by industry) for creating a smart building. Over the 2010s, research tended to focus on remaining deeply involved in only single issues or value drivers.

Through an analysis of the author's peer reviewed and published works (book chapters, articles, essays and podcasts), supplemented with additional contextual academic literature, a model for how the key drivers for creating a smart building have evolved in industry during the 2010s is presented. The critical research commentary within this thesis, tracks the incremental advances of technology and their application to the built environment via academic movements, industrial shifts, or the author's personal contributions.

This thesis has found that it is demonstrable, through the chronology and publication dates of the included research papers, that as the financial cost and complexity of sensors and cloud computing reduced, smart buildings became increasingly prevalent. Initially, sustainability was the primary focus with the use of HVAC analytics and advanced metering in the early 2010s. The middle of the decade saw an economic transformation of the commercial office sector and the driver for creating a smart building was concerned with delivering flexible yet quantifiably used space. Driven by society's emphasis on health, wellbeing and productivity, smart buildings pivoted their focus towards the end of the 2010s. Smart building technologies were required to demonstrate the impacts of architecture on the human. This research has evidenced that smart buildings use data to improve performance in sustainability, in space usage or for human-centric outcomes.

Contents

Tables and Illustrations

Accompanying Works

1. Brown, K., et al., 2016. *Environmental Sustainability Principles for the Real Estate Industry*, Davos: World Economic Forum.

2. Yang, T., Clements-Croome, D. & Marson, M., 2017. *Building Energy Management Systems*. In: M. A. Abraham, ed. Encyclopaedia of Sustainable Technologies. London: Elsevier, pp. 291-309.

3. Clements-Croome, D., Marson, M. & Yang, T., 2017. *Planning and Design Scenarios for Liveable Cities*. In: M. A. Abraham, ed. Encyclopaedia of Sustainable Technologies. London: Elsevier, pp. 81-97.

4. Clements-Croome, D., Marson, M. & Yang, T., 2018. *Research Roadmap for Intelligent and Responsive Buildings,* Amsterdam: International Council for Research and Innovation in Building and Construction.

5. Clements-Croome, D., Marson, M. & Yang, T., 2018. *The Journey Towards Creating Intelligent Buildings*, Amsterdam: International Council for Research and Innovation in Building and Construction.

6. Marson, M., 2018. *The Business Value of an Innovative Building*. Corporate Real Estate Journal, 8(2), pp. 154-164.

7. Marson, M. & Kinch, J., 2020. *The Challenges of Retrofitting Smart Systems Into Existing Buildings*. Royal Institute of Chartered Surveyors Journal.

8. Marson, M. & Goncharov, K., 2020. *The Misleading Simplicity of Smart Cities*. Intelligent Buildings International.

9. Marson, M. & McAllister, J., 2020. *The Human Connection to an Intelligent Building*. Intelligent Buildings International.

10. Various Podcasts, Marson, M., et al (list in appendix A)

Acknowledgements

I would like to thank Dr Rosa Schiano-Phan and Dr William McLean for their advice and guidance in the preparation of this research work. I would also like to thank Jamie-Leigh Chapman for her sustained support over the years and Nick Offer for his inspirational leadership.

For those that I have fought with - look what we achieved.

Declaration

I declare that all the material contained in this thesis is my own work.

1. Introduction

Contemporary existing literature in the field of smart buildings is often concerned with the very specific and nuanced definitions for practice, point solutions[1] and proprietary technologies. Although there is no agreed consensus in academia or industry (as demonstrated at the beginning of each of the podcast transcripts presented in this thesis (Various Podcasts, Marson, M., et al.)), the below definition is regularly cited:

> "An intelligent building is one that is responsive to the occupants' needs, satisfies the aims of an organisation and meets the long-term aspirations of society. It is sustainable in terms of energy and water consumption and maintains a minimal impact to the environment in terms of emissions and waste. They are also healthy in terms of well-being for the people living and working within them and are functional according to the users' needs." (Clements-Croome, 2014)

The far-reaching nature of technology and its ability to form part of a solution for many issues means that definitions have the potential to be laboursome and overly specific. It is possible to build on this definition by broadening it and defining a smart building as one that uses data to improve performance or outcomes in sustainability, space usage or for sapiens[2]. In section 6, this commentary will present a model to support this definition, provide examples of their measurement and justify this definition.

[1] Solving a particular problem with disregard for related problems
[2] Human-centred outcomes such as productivity, health and well-being and engagement

Although beyond the scope of this commentary, it is important to set the agenda by defining smart and intelligent buildings/cities as the same.

1.1 A Growing Body of Literature

The joint working group of the International Council for Research and Innovation in Building and Construction (CIB), the Chartered Institution of Buildings Services Engineers (CIBSE) and the Continental Automated Buildings Association (CABA) has been producing academic research on smart buildings. Such works have strong technology and human-centred aspects, but centre primarily around automation and its effect on operational efficiency and occupant comfort. The body of research concerned with implementations and real-world examples has been growing, acting as an emerging means for the definition of a smart building and its functionality. This thesis will resolve to demonstrate how the functionality of a smart building, and therefore its evolving definition changed, from an industrial perspective, during the 2010s (figure 1). Specific journals, such as the Intelligent Buildings International Journal, exist to document, discuss and propose topics linked to the field of research. Other built environment journals have increased their publishing in the field in recent years, as its corporate popularity has grown.

There is an emerging yet extensive body of work from Original Equipment Manufacturers (OEMs) that discusses the benefits of smart buildings. How balanced and objective this work is, is debatable given their vested interest in a set of commercially successful products. Their contributions, however, are well researched, reasoned and referenced. In particular, the papers that Mitsubishi’s subsidiary ICONICS offers gleans insight into real-world applications and has a robust scientific method. From the vast swathes of grey literature[3] written about smart buildings, it is evident that designers and operators are fulfilling the ambitions of those writing about the mere possibilities (Buckman, et al., 2014). Despite some inherent sales bias, the grey literature offers valuable insight into practical application methods and real-world lessons learnt. As a rapidly advancing topic, the smart buildings domain is subjected to the whim of trend. For example, the need for platforms[4] was most discussed between 2014-2018, before being overtaken by user experience mobile applications from 2018 to the present day. To further conflate the aforementioned corporate issues, those with a traditional supplier role in the construction process are using the terminology of technologists in misleading ways to suggest new capabilities for their existing systems and in situ implementations. Such behaviour has led to a notable distrust and an exacerbation of confusion across both industry and academia (Okraglik, 2019).

Smart buildings, by the nature of their systems integration, are at odds with a highly specialised and divergent set of players. They need both specialists and generalists to make a design work. The coalescence of the different parts of the value chain in construction presents challenges that limit the success of what a designer sets out to achieve with a smart building. The construction process is designed to manage and reallocate risks to other parties (Smith, et al., 2014). Given the concerns of those implementing technologies for the first time around

[3] Research and materials produced outside of traditional academic publishing
[4] A digital environment in which a set of applications are executed. For a smart building this is typically infrastructure to acquire, orchestrate, normalise, transform and visualise data.

potential litigation, the smart building industry has made limited progress[5] as risk management techniques have been successful in stifling innovation.

This thesis serves to add to the architectural body of knowledge to record, synthesise and analyse real-world technology implementations and their architectural impacts. Anxiety of new practice (and the associated liability) combined with the advertising hyperbole published by the equipment manufacturers, has led to a dearth of academic texts about the technological advances of smart buildings and their outcomes. The motivation for this thesis is to document the incremental advances of technology and its application to the built environment; be that in academic movements, industrial shifts or personal contributions. Beyond the perceived 'glitter' of innovation, this thesis aims to describe the tangible value proposition of a smart building and how its description has morphed over the past decade.

1.2 A Brief History

The contemporary history of architecture has demonstrated great change since the turn of the twentieth century due to technology (Frampton, 2007). In fact, "Smart environments have a long, deeply imperfect track record, dating back at least to the 17th century, when Dutch inventor Cornelis Drebbel created one of the first feedback-controlled devices: a thermostat that regulated airflow in a chicken incubator, based on temperature. Progress since then has been impressive, particularly in terms of efficiency (think energy and time savings), comfort or wellness (temperature, air quality, sound, lighting, and so on), and

[5] In terms of becoming a standard set of design processes in the RIBA Plan of Work, or 'rule of thumb' inclusions in best design practices

safety (detecting fire, revealing gas and water leaks, and other self-diagnostics)” (Bernstein, 2020).

Opening the 1964 *Architecture and the Computer* Conference at the Boston Architectural Centre, Walter Gropius, referring to computing capabilities, wrote: “It will certainly be up to us architects to make use of them intelligently as means of superior mechanical control which might provide us with ever-greater freedom for the creative process of design” (Gropius, 1964).

The more sceptical would point out that computing capability is only required to correct poor design during the operation of a building. Beyond simple automation, the most prevalent research into early forms of smart buildings were referred to as cybernetics. “Coined as a term by Norbert Wiener in 1948, cybernetics…revolved around the notion of feedback: a set of messages, exchanged without regard to their content, that control a system. A system undertakes an action, receives information about its performance, and corrects its course accordingly, not unlike the steersman of a ship” (Steenson, 2017). By the middle of the 1960s, architects such as Cedric Price and Christopher Alexander were using cybernetics to demonstrate how feedback loops in the context of dynamic systems would challenge design problems. Architecture is a very self-reflective vocation – the most successful developments of the cyberneticists revolved around the process of design. This started the Computer Aided Design (CAD) paradigm and, unlike smart buildings, went on to be ubiquitous and even synonymous with drafting. At the time, the cyberneticists believed CAD could not “occur without machine intelligence” (Negroponte, 1972).

Cybernetic architecture seemed to be confined to paper architecture owing to a lack of genuine technological advancement in the real-world – not just the science fiction of the architect’s imagining. Famously, Cedric Price’s Fun Palace (1963-1967, unbuilt) typified the era’s thinking of smart buildings and is a notable precursor to the smart building movement. Schemes such as the Fun Palace demonstrate the unaffordability of the technology (amongst other reasons), at the time, to realise the design.

The most tangible body of work is the output of Massachusetts Institute of Technology’s Architecture Machine Group (MIT’s AMG) – founded in 1967, which combined architects and electrical engineers. The group today is known as MIT Media Lab. The Lab and its notable academics – such as Carlo Ratti – are thought leaders of the convergence of digital and architecture.

The opportunities afforded by technological advances since the millennium, in a comparatively short amount of time, have led to a point where silicon technologies and their associated methods of connectivity have enabled the creation of smart buildings, as they are understood today:

> “Smart technologies mark the convergence between very cheap devices that collect parametric data to detect a state change of some physical entity and a computational system of recording and even further, response” (Stimmel, 2015)

The connected devices market grew from 6 billion devices in 2006 (Gartner, 2017) to a projected 43 billion devices by the end of 2023 (McKinsey & Company, 2019). In a similar timeframe, cloud application usage is projected to grow at a rate of 16% annually (Gartner, 2019). It is the current low cost of simple sensing devices and the ubiquity of cloud computing that have opened the door to the possibility of designers and operators employing the talents of computing, including data capture and recording, automation, and statistical forecasting.

> “Man-computer symbiosis is an expected development in cooperative interaction between men and electronic computers. It will involve very close coupling between the human and the electronic members of the partnership.” (Licklider, 1960)

Speaking at a conference in Zurich in 1934, Mercel Breuer said that the “…origin of the Modern Movement was not technological for technology had been developed a long time before… What the new architecture did was to civilise technology” (Breuer, 1934). In writing this commentary in 2022, hindsight shows that architecture is, again, being used to “civilise technology”. This research demonstrates that the contemporary equivalents to the Modern movement are cloud computing, IoT-technologies and user interactions. The ways in which people interact with the digital services provided by a smart building are akin to how the Modernists civilised technology by creating different human experiences, as a result of the application of new, but ‘hidden’, technologies. Evidence suggests that smart buildings are at a stage similar to that of early mechanical comfort cooling:

> "…the history of air-conditioning is almost the classic example of a technology applied… to correct grossly deleterious atmospheric conditions, and then slowly sophisticated..." (Banham, 1984)

Now that our environments have been corrected to match the expectations of the Modern age, designers must concern themselves with the sophistication of its application.

2. Research Gap, Aims & Objectives

2.1 Research Gap

Specialist research bodies have failed to provide a holistic view of the changes in the prominent value lever (as driven by industry) over the 2010s, instead remaining deeply involved in only single issues/value levers (i.e. sustainability, space or sapiens). Therefore, there is little to no academic research available on the holistic evolution.

2.2 Aims

This thesis proposes to deliver on the below aims:

1. To reflect on the author's previous publications as a coherent body of work that contributes to the advancement of the built environment disciplines;
2. To define the value of a smart building;
3. To capture the key trends and technologies that make a smart building;

2.3 Objectives

This thesis proposes to deliver on the below objectives:

1. To demonstrate and evidence the changes, over time, of the primary functionality of a smart building;
2. To evidence the wide range of industrial contributions to academic research in the smart buildings field;
3. To propose a model for the evolution of the primary driver for creating a smart building in the 2010s.

3. Methodology

This research has focused on the documentation, discovery and analysis of the application of smart buildings technology to the built environment. Through the process of PhD by published work, this commentary serves to explain how the works selected for inclusion in my thesis consist of a coherent and original contribution to the knowledge of the field of the built environment disciplines.

The commentary presents a brief history of smart buildings (§1) to allow the reader to understand the significant change that technological innovation has had on architecture in the past decade. The publication of the author's works acts to capture the zeitgeist of design in the built environment (figure 2) by discussing the pertinent topics and the associated complexities of integrating technology. From these learnings, this commentary presents a framework for how the value of smart buildings has been derived and how it has changed over time.

Since 2014, the author has undertaken research relating to the delivery of smart buildings and cities projects as part of their employment. These have included: a) a European practice (Connected Spaces) lead role at technology and management consulting firm Accenture; b) founder and Head of Smart Places at global engineering design consultancy, WSP; and c) more recently, Global Market Sector Director for Technology at built and natural asset consultancy, Arcadis.

The author's mission has been to capture the learnings from real-world applications of emerging technologies to the built environment. Working primarily with the Chartered Institution of Building Services Engineers (CIBSE) Intelligent

Building Group (IBG), the author worked with academics to shape and produce peer-reviewed research. In addition, the author's technology and architectural designs are part of the below notable (non-exhaustive) buildings and cities:

Completed Buildings	**Buildings Under Construction** (as of January 2022)	**City Masterplans**
Twentytwo Bishopsgate, London	Soho Place, London	Dublin Docklands, Ireland
The Dock, Dublin	Paddington Square, London (Renzo Piano Buildings Workshop)	NEOM Industrial City, Kingdom of Saudi Arabia (Bjarke Ingles Group)
Cisco Campus, Bangalore	Red Sea Airport, Kingdom of Saudi Arabia (Foster + Partners)	Diriyah Gate, Kingdom of Saudi Arabia
Salesforce Tower, San Francisco	Unity Place, Milton Keynes (LOM)	

Table 1: Schemes contributed to by the author

It has only been in the last decade that IoT technologies have been applied, in earnest, to architecture and the built environment. The speed of change has increased as a result of pressure from businesses to innovate within their real estate. The combination of these factors has meant that adequate reflection has not yet been performed or recognised in a significant way within existing academic literature. The commentary of this thesis provides a brief rationale for the works presented and solves the scarcity of industry case studies and documented experimentation.

4. The Importance of Smart Buildings

Our exposure to smart buildings through popular media presents differing views of capability but similar sentiment towards them. The Heuristically programmed ALgorithmic Computer, HAL 9000, featured in Kubrick's film, '2001: A Space Odyssey' (1968), depicts a malevolent and preservationist system that would jeopardise the lives of its crew. By 2001, The Ultrahouse 3000 in The Simpsons (The Simpsons: Treehouse of Horror XII (S13, E1), 2001) keeps the sentiment alive by depicting a smart home that tries to kill Homer. Most recently, Dwayne Johnson's blockbuster, Skyscraper (Skyscraper, 2018) highlights the safety and security perils of installing smart building technologies. Despite the fantasy architype of a smart building, owner and occupier demand is hastening our transition from traditional to smart buildings.

As our exposure to digital products and services increases, so do our expectations of the built environment. Our video streaming services are able to learn our entertainment preferences and anticipate our needs. Our buildings largely, remain static in terms of temperature, work setting variety and the interactions that they facilitate – the pace of change is incomparable with digital capabilities. Services such as Apple Pay have replaced the need for physical bank cards, yet it is commonplace that office workers carry a physical security badge for their office. Amazon is able to deliver almost any item for the following day, yet a maintenance issue in a building can take weeks to rectify. A growing tension between the realities of our buildings and our digital experiences means that:

> "Digital is no longer the centrepiece of brand experience. Emphasis is shifting onto how best to use it as an invisible enabler of physical and sensory experiences. As interactions with users evolve from periodic engagements via a screen to consistent, connected experiences, organizations must create new services that are deeply integrated in the physical world. A major shift is underway in technology, fuelled by lower costs, users' growing angst about their "screen addiction," and the disaggregation of core technology components, such as cameras, microphones, speakers and screens, which are increasingly being embedded in an array of different environments — especially in the home […].From Airbnb to Amazon, Deliveroo and Alibaba, a growing number of primarily digital brands are now placing greater emphasis on physical presence while making the most of digital and data to improve experience (Fjord, 2018)."

Beyond experiential benefits, smart buildings are helping owners and operators close the design-performance gap post-occupancy (Pelsmakers, 2012). Low-cost sensing technologies are able to give insight into poor performance. Combined with analytics from large experiments and vast research, suggested interventions allow us to reduce the performance gap (Clements-Croome, 2014).

The pace of the change that we are all responding to is increasing (Fjord, 2019). For organisations, their buildings and the architectural qualities that they deliver have never been more important (Smith, 2019). For Deloitte, delivering The Edge[6] as a globally prominent smart building was an important part of launching the Deloitte Digital capability. Traditionally, the business is considered as an audit and accounting firm and it was experiencing difficulty in getting client organisations to trust them in technology advisory projects. By being the anchor tenant[7] of a smart building, they were able to attract the necessary talent to be a contender in a highly sought-after market (Ubels, 2017). In addition to providing curb appeal[8], the technologies within the building enabled one of the highest BREEAM scores in Europe and allowed the occupants to control their environment using a mobile application. Additionally, the building provided the business with data on how the space was being used to ensure that they could extract as much value as possible from their limited space (Ubels, 2017). The Edge project acted for many as the flagship for the strategic business value that a smart building could provide. The Edge was the case study that enabled the author to secure financial investment from Accenture leadership to build The Dock in Dublin.

At the Building Services Research and Information Association's (BSRIA) 2017 Soft Landings Conference, Peter Clegg (Clegg, 2017) spoke of the realities of the thermal and energy consumption performance gap in architecture. The understanding of the performance gap has since been expanded to consider

[6] A commercial building developed by OVG, widely regarded as the smartest building at the time
[7] A significant tenant that attracts other tenants to a build and/or provides financial justification for moving forward with a scheme
[8] Attractiveness of a property

occupant experience, health and wellbeing, productivity and more. Our building stock is still of relatively poor quality when compared to the technologies that can be deployed within. Performance of the physical world is lagging behind the sensing technology and is exacerbating the mismatch between the digital and physical worlds (Salam, D., 2019).

The combination of changes in what society expects from architecture (against digital services), the concern over the design-operations performance gap of our buildings and the business imperative to data-enable our spaces provide a compelling set of reasons for the importance of smart buildings. These reasons at the building scale are easily translatable to the city scale (§6.5).

5. Discussion of Works

To establish the context of the works in this thesis, a brief set of reflections towards the pertinent messages, contributions/originality to the architectural sphere of knowledge and the method of production are presented below.

5.1. Environmental Sustainability Principles for the Real Estate Industry

Brown, K., et al., 2016. *Environmental Sustainability Principles for the Real Estate Industry*, Davos: World Economic Forum.

5.1.1 SUMMARY: The first paper – published in 2016 – was part of a commission for the World Economic Forum, looking at the environmental sustainability principles for the real estate industry. The paper showed how buildings are responsible for 40% of global carbon emissions (IPCC, 2013), yet as a collective set of industries – architecture, engineering and construction (AEC) – they lag in sustainability performance against others (sustainability performance pertains to carbon emissions – during construction and operation), energy and water consumption as well as asset lifespans. As a result, the paper considered the substantial climate change risk that the architecture, engineering and construction industries pose to the planet. One of the key considerations was how sustainability performance improvements will be a delivered by the latent potential of the technologies already installed in buildings, or technologies that can be easily retrofitted. To conclude, a set of smart buildings technologies and their benefits were presented as a way for real estate industry leaders to act in reducing the potential for their climate impact.

5.1.2 RESEARCH GAP: How smart buildings technologies are being implemented to improve the sustainability performance of the AEC industries.

5.1.3 METHODS: As part of the report's discussion for a way forward, the research culminated in a variety of methods and systems that could increase the sustainability performance of the AEC industry. It was important to make certain that the solutions presented had proven benefits to ensure efficacy of the report. Traditional research methods of document screening, case study analysis, interviews, and observation, combined with consulting techniques culminated in the peer reviewed report.

5.1.4 IMPACT: This research had societal impact, bringing the research to the attention of influential leaders. With over 3.5 million followers on LinkedIn, a publication for the WEF has a reach greater than most academic journals.

5.1.5 ORIGINALITY: Such a research-heavy, yet practical set of actions for leaders to take, made for a novel contribution to the 2016 World Economic Forum. This audience, in particular, had not had a similar paper presented before. Set in the context of sustainability, it gave a unique view to the Industry Council Agenda.

5.1.6 CONTRIBUTION: Matthew Marson is not formally credited with contributions to this work as it was created on behalf of the publisher, World Economic Forum (WEF), as a commercial endeavour. The author of this thesis was the primary researcher whilst employed by Accenture. It is unusual for researchers/writers to receive individual credit during employment at a consultancy. Marson's contribution was one of primary research, shaping of the structure, creation of research outcomes and synthesis of the piece. There were multiple stage-gates of review from seniors at Accenture and the credited review body at the WEF.

5.1.7 CONTEXT: This paper sets a strong foundation for the complexities of the integration of technology into the built environment. It supports the next paper in setting a financial reason for further technical research.

5.2. Building Energy Management Systems, Encyclopaedia of Sustainable Technologies

Yang, T., Clements-Croome, D. & Marson, M., 2017. *Building Energy Management Systems*. In: M. A. Abraham, ed. Encyclopaedia of Sustainable Technologies. London: Elsevier, pp. 291-309.

5.2.1 SUMMARY: This chapter in the Encyclopaedia of Sustainable Technologies demonstrated the complexity of modern buildings, and how that complexity has increased in line with the comfort expectations of inhabitants. These expectations reached a point where mechanical and electrical plants were required to combat the failings of the architectural design and/or specific uses of the spaces (Bougdah & Sharples, 2010). In order to deal with that level of complexity in the mechanical plant, it was necessary for the industry to create an Information Communications Technology (ICT) - based control system that can automate actions as necessary. To date, these have been operated on a schedule with alarm and event-based technologies. Today, advanced users are incorporating other data sources, such as the weather to enhance the intelligence of operational decisions that the system makes (Clements-Croome, 2014).

Large-scale connectivity from several buildings can also balance power between them and create sharing networks (Stimmel, 2015). Concluding, a model for how Building Energy Management Systems (BEMS) has changed over the years was presented. Furthermore, this paper demonstrates how BEMS act as the fundamental backbone to a smart building (Yang, et al., 2017).

5.2.2 RESEARCH GAP: The development of BEMS from simple automation systems to intelligent controls.

5.2.3 METHODS: A robust literature review of 45 academic papers across the themes of intelligent buildings, building services and energy management, presents the advancement of BEMS in its historical context. Practical experience added further insights to the models and analyses presented.

5.2.4 IMPACT: The Encyclopaedia acts as an academic reference work from Elsevier, a core text for other to base their research developments from.

5.2.5 ORIGINALITY: Although there is now an extensive body of literature on the topic of BEMS and architectural performance, at the time of publishing, this paper presented a new analytical model for considering the recent technological (predominantly machine-learning driven analytics) advancement.

5.2.6 CONTRIBUTION: Marson provided research to capture the common uses of the technology used, the industry case study and technical assurance.

5.2.7 CONTEXT: The paper supports in the understanding of the technological advancement required in the early stages of smart buildings to support the reader's understanding of scale and complexity for the next work.

5.3. Planning and Design Scenarios for Liveable Cities, Encyclopaedia of Sustainable Technologies

Clements-Croome, D., Marson, M. & Yang, T., 2017. *Planning and Design Scenarios for Liveable Cities*. In: M. A. Abraham, ed. Encyclopaedia of Sustainable Technologies. London: Elsevier, pp. 81-97.

5.3.1 SUMMARY: This chapter in the Encyclopaedia of Sustainable Technologies presents the ways in which a place gives people their quality of living and supports meeting some elements of Maslow's hierarchy of needs (Maslow, 1943). The work sets out how the systems that designers put into a city, allows one place to outperform another on essential outcomes such as flooding, community, energy, and more. Throughout, the narrative of the work supports the conclusion that digital capabilities are the mechanism through which a city's set of core capabilities, and their associated outcomes, are created. It is the hypothesis that these systems will act as an ignition for the invention of contemporary competitiveness between cities (Clements-Croome, et al., 2017). The paper demonstrates how smart city capabilities will have population scale consequences. To conclude, it is demonstrated how technology will rechart the lessons that have been learned by planners and designers from past urbanisation projects.

5.3.2 RESEARCH GAP: A convergence of key population indicators as a result of city-scale technological improvements.

5.3.3 METHODS: Extensive traditional literature review from over 40 sources with numerical analysis were employed to craft this chapter in addition to materials developed as part of some consulting engagements for national governments.

5.3.4 IMPACT: The Encyclopaedia acts as an academic reference work from Elsevier.

5.3.5 ORIGINALITY: This contribution is of particular importance to demonstrate that this thesis is a cohesive body of work. The way that it deals with a scale much larger than that of an individual building highlights the similarities in the design of technology for buildings and cities. Additionally, it presents the importance of demographic and economic drivers for how technology in the built environment has a measurable and significant impact on the lives of citizens.

5.3.6 CONTRIBUTION: Marson was responsible for some of the ideation of the topic, the entirety of part 2 and its numerical analysis as well as supporting the other authors (predominantly part 3) to ensure a cohesive research work.

5.3.7 CONTEXT: With a baseline established for effects of technology on people this work acts as a foundation along with the previous works for an understand of the tactic presented in the Research Roadmap.

5.4. Research Roadmap for Intelligent and Responsive Buildings

Clements-Croome, D., Marson, M. & Yang, T., 2018. Research Roadmap for Intelligent and Responsive Buildings, Amsterdam: International Council for Research and Innovation in Building and Construction.

5.4.1 CONTEXT & RESEARCH GAP: Created for the International Council for Research and Innovation in Building and Construction, the Research Roadmap for Intelligent and Responsive Buildings is a collection of essays that discusses, primarily in the context of intelligent buildings, the importance of issues such as:

- The prevalence of daylighting, and its measurement through the use of Internet of Things devices, to improve health and well-being outcomes for the inhabitant of a particular space;
- How Intelligent Buildings drive the attractiveness of the workplace as the battleground for a corporate war for talent[9], as well as the infrastructural and digital needs of buildings to realise flexible, modern outcomes for the workplace;
- A consideration of the future of Intelligent Buildings more broadly.

This work aims to, briefly, provide some guiding research in research gaps pertinent at the time of publication.

5.4.2 CONTRIBUTION: In addition to writing one of the essays as sole-author, Marson supported in the editing of this collection of works as part of his role in CIBSE's Intelligent Buildings Group. The roadmap serves to bring cohesion to a set of peripheral issues surrounding smart buildings.

[9] Competitive methods for acquiring and keeping skilled employees (Kane, et al., 2017)

From the historical aspects covered in the introduction of this commentary and the seemingly disparate set of issues that are generated by the discussion of the technology in the built environment, the roadmap editorial process was one of selecting common consequential discussions that smart buildings often lead to. Selection and invitation to authors was borne from professional experience and academic curiosity.

Technology Aware Workplaces

5.4.3 SUMMARY: This essay matches the changes that digital has brought to businesses and the associated need for the change that workplace architecture has yet to solve for them.

5.4.4 RESEARCH GAP: A support study to help workplace operators interpret and validate a prominent market study.

5.4.5 METHODS: The research in this essay sets the research of Stoddart in the context of smart buildings through observations and reflections of experiences with blue-chip companies. The first-hand challenges witnessed first-hand from The author’s role was to translate the outcomes of Stoddart and other first-hand witnessed challenges into spatial and technological responses. The essay situates academic research in a real-world content to substantiate the claims of research.

5.4.6 IMPACT: With an SJR[10] in the second quartile, the publication had a good academic impact with further proliferation into application in industry.

5.4.7 ORIGINALITY: Traditionally, architectural academia has been primarily focused on the theoretical, representational and formalist aspects of architecture. The business outcomes generated by good architecture only seem to be tackled by organisations such as Leesman. The Leesman Index (Leesman, 2018) is a method that allows organisations to measure employee experience. Other than the Stoddart Review (Stoddart, 2016), which predominantly focuses on delivery productivity through culture, other substantive work on the business outcomes of well-designed workplaces outside of practice-led studies are missing from our academic body of knowledge. Despite this limitation, Stoddart combines the foundational research of others with supplementary experimental results to provide a critical and reliable study.

5.4.8 CONTEXT: This paper sets the commercial boundaries for the application of academic research industry and allows the reader to start to understand the connection between the space and sapiens value levers.

5.5. The Journey Towards Creating Intelligent Buildings

Clements-Croome, D., Marson, M. & Yang, T., 2018. The Journey Towards Creating Intelligent Buildings, Amsterdam: International Council for Research and Innovation in Building and Construction.

---

[10] Scientific Journal Ranking – a measure of scientific influence of scholarly journals

5.5.1 SUMMARY: The Journey Towards Creating Intelligent Buildings is a paper that introduces the methodology of design thinking as a response to the importance of designing quality experiences as the fundamental consideration in the creation of a smart building. The paper presents examples of different technologies that have been implemented in past projects and that support the three value levers[11] of sustainability, space and sapiens presented in this commentary (§6). The work continues to make recommendations as to how a designer can counteract the difficulties of the implementation of smart building systems and presents a set of mitigation strategies. Most notably, this paper considers the value lever of space.

5.5.2 RESEARCH GAP: Evidence of the impact of design thinking as a methodology for designing smart buildings.

5.5.3 METHODS: Synthesis of experience in practice and screenshots from the User Experience (UX) technology presented at The Dock demonstrate the application of the research to a built project. An academic literature review substantiates the claims and contextualises the relevance and importance of contribution.

5.5.4 IMPACT: With an SJR in the second quartile, the publication had a good academic impact with further proliferation into application in industry with the peer reviewers noting the high-level of quality of examples previously unseen in their roles.

[11] A set of actions, methods or technologies that can be employed to realise outcomes that align to a common purpose.

5.5.5 ORIGINALITY: This is the first time that design thinking as a methodology has been discussed in the context of smart buildings. To further support this claim, there are no supporting notable references beyond a conference in which the workplace design lead of WeWork talks about his design process.

5.5.6 CONTRIBUTION: Marson authored the majority of the paper, supplied almost all examples with support from co-authors for shaping.

5.5.7 CONTEXT: This work is an important component of the body of the thesis as it grounds the theory presented in the earlier papers with real-world application and the associated learnings. The experiences presented are culminated from management consulting, engineering and academic contexts. It acts as a foundational study to the following paper.

5.6. The Business Value of an Innovative Building

Marson, M., 2018. *The Business Value of an Innovative Building*. Corporate Real Estate Journal, 8(2), pp. 154-164.

5.6.1 SUMMARY: This essay discusses the expectations of the experience that an inhabitant has of architecture and their workplace. It compares those expectations with the changing nature of the interaction that is expected as a direct consequence of the experiences they have had with other digital consumer technologies and platforms, such as Netflix or Amazon. As an example, the ubiquity of delivery services of purchases to our homes has led organisations such as VenueNext to offer at-seat dining options for those watching sporting events at the Chase Centre in San Francisco. The experience of home shopping has evolved to delivery services within the built environment. The paper demonstrates the direct link between the societal digital megatrends and the application of smart building technologies. Examples of those technologies and the value that they generate are presented in a framework. This work represents a set of case studies that evidence the ability of smart buildings technologies to influence the outcomes of the three value levers, in the model presented as part of this commentary. Screenshots of the deployed systems are shown to support energy conservation and cost reduction, space utilisation for activity-based work settings and location services that enable internal wayfinding and skill matching.

5.6.2 RESEARCH GAP: Definition of the value created from the application of smart building technologies.

5.6.3 METHODS: The content for this work was generated as part of a series of consulting engagements that Marson completed for Fortune 500 clients whilst at management consulting firm, Accenture. Desk-based research and learnings from client Corporate Real Estate (CRE) departments culminated in the development of the megatrends outlined in this work. The framework was generated as a result of qualitative research in the form of interviews conducted with the leaders of CRE departments (such as Head of Real Estate at Microsoft and Global Workplace Technology Lead at Salesforce) and facility management firms (such as the Head of Strategic Growth at ISS and the Director of Digital Transformation at Mitie). The results of the paper came from comparing the business metrics (such as sick days, space utilisation, energy consumption), on a normalised basis, of the former Accenture building to the new space at The Dock.

5.6.4 IMPACT: With an SJR in the second quartile, the publication had a good academic impact with further proliferation into application in industry with the editor noting strong feedback following publication.

5.6.5 ORIGINALITY: As noted in the returned comments as part of peer review process, this is the first time that a smart building project had cited the measurable impacts that the technology had on the architecture and the business. Furthermore, the editor specifically sought Marson as an author to help introduce their readership to real-world examples.

5.6.4 CONTRIBUTION: Sole-authored.

5.6.7 CONTEXT: This paper sets the financial drivers for organisations implementing a variety of smart building technologies and validates the continuation of the research across academia and industry.

5.7. The Challenges of Retrofitting Smart Systems into Existing Buildings

Marson, M. & Kinch, J., 2020. *The Challenges of Retrofitting Smart Systems into Existing Buildings*. Royal Institute of Chartered Surveyors Journal (RICS Journal).

5.7.1 SUMMARY: This paper intends to support designers and surveyors to ground their expectation on what is possible for the retrofit of smart building technologies and associated systems in existing buildings. The paper considers the practicalities of being able to do so through new data standards (such as

Haystack, Brick and Manufacturer Usage Descriptions (MUD)), that mean old systems can now be more manageable and less costly to integrate. Going a step further, the work explores how newer (in comparison to the standard techniques employed in the controls industry) IoT procedures and standards will support the mitigation of known and existing security loopholes found within incumbent systems and traditional controls methods. Furthermore, it considers the outdated skills that built environment professionals currently have and the skills acquisition required to make substantive progression for the industry. In August 2020, The Royal Institute for British Architects released a report in which it detailed the ways in which it is planning to alter architectural education and introduce continued and regular skills assessments to ensure that the skills of architects are fit for the future (RIBA, 2020).

5.7.2 RESEARCH GAP: An analysis of how smart buildings should be commissioned to maximise future compatibility.

5.7.3 METHODS: Using industry observations, evidenced by completed projects and experiments, quantitative techniques are presented as application methods. The skills and knowledge section came from Marson's experiences of working on a variety of schemes currently under construction in London and across the world.

5.7.4 IMPACT: All ~140,000 RICS members receive a copy of the journal, meaning there is a large readership. The publication has generated follow-on consulting opportunities. The skills and knowledge were well tested on design teams and had been developed into a formal course called Smart Building Bootcamp.

5.7.5 ORIGINALITY: This work represents the insights generated from some of architecture's first implementations of smart building systems to both new (such as Twentytwo Bishopsgate, London and Unity Place, Milton Keynes) and retrofit buildings (such as the Cisco Campus in Bangalore). The completion of these projects contributes to the knowledge of architecture more broadly. It also highlights the experience of the design teams involved and the skills and knowledge they had to attain for successful project delivery.

5.7.6 CONTRIBUTION: Primary author, supported by co-author in review.

5.7.7 CONTEXT: This paper is a necessary component of this thesis as the works discussed, funnel from the theoretical to the practical and deliverable. It evidences system architecture examples and the calculated benefits realised.

5.8. Special Edition of Intelligent Buildings International

Marson, M., et al., 2020. *The Impact of the 4th Industrial Revolution on Design and Management of Buildings and Cities*, London: Taylor & Francis.

5.8.1 CONTEXT: This special edition of Intelligent Buildings International, entitled *The Impact of the 4th Industrial Revolution on Design and Management of Buildings and Cities*, was born out of an event organised through the Intelligent Buildings Group of the Chartered Institution of Building Services Engineers (CIBSE). With presentations from industry leaders and the author's WSP team, Marson worked with the editor of Intelligent Buildings International to capture our content as peer-reviewed journal submissions.

5.8.3 IMPACT: With an SJR in the second quartile, the publication had a good academic impact. Intelligent Buildings International is a relatively junior and niche publication (started in 2009) which has a growing readership and improving research impact.

5.8.2 CONTRIBUTION: As well as being lead author on two papers, Marson supported the other contributors in shaping their own work. The author selected the original speakers for the event and subsequently invited some additional contributions to provide further context and insight to an emerging topic for the field of smart buildings. Reflecting, Marson enjoyed shaping the storyline and selecting elements to create a cohesive body of work.

5.8.4 CONTEXT: This work demonstrates the notable step-change in the complexity of the technologies discussed in earlier papers and the learnings as a result of poor implementation examples from the last 8 years.

The Misleading Simplicity of Smart Cities

5.8.5 SUMMARY & RESEARCH GAP: This paper, presents how the vogue of Smart Cities has led to the oversimplification of the representation of the components required to deliver a successful system or Smart City. These lessons are transferable to Smart Buildings, albeit at a different scale. Importantly, this paper demonstrates the synergies between both the buildings and the city scale with regard to the design and deployment of a systems' architecture. The work further discusses and elaborates on the permutations of the devices needed and their resultant interactions with other systems. The outcome is the demonstration of the comparatively innumerable possibilities in data acquisition, transfer, and manipulation versus the simplified stack diagram. Finally, the paper concludes and laments the historic role of the architect as generalist. It goes to consider how the role of the generalist is preferred over that of the specialist when designing a Smart City.

5.8.6 METHODS: First-hand design work and a synthesis of the experience denotes this as primary research. It builds on the principles of design at the scale of a building and translates the techniques and considerations to the scale of a city.

5.8.7 ORIGINALITY: The learnings from this paper have been derived from working on the first-of-a-kind fourth industrial city for the Saudi Arabian Crown Prince with Bjarke Ingles Group. In translating the requirements to a practical set of delivery steps, and a procurable and buildable set of elements, there were a lot of lessons learnt and fierce conversations with client stakeholders and others in the design team. This works captures those lessons.

The Human Connection to an Intelligent Building

5.8.8 SUMMARY & RESEARCH GAP: To date, smart buildings technology has made for some burdensome and clumsy human interaction experiences in architecture. Through the preoccupation of technology as the primary driver, designers have forgotten to craft holistic architectural experiences. Interaction design is presented as an opportunity to create meaningful relationships between a user, their space and a set of digital services. As smart buildings technology has progressed, users now have new, more active and interactive methods to engage with and control a space. This provides architects with enhanced social interaction potentials, through the data enablement of people, location, and other sources.

5.8.9 METHODS: By using real design artefacts from the interaction designers on a delivered project, the paper demonstrates the care and attention a contemporary architect must place into a holistic digital/physical experience. The paper presents design thinking as a methodology to deliver the outcomes presented.

5.8.10 ORIGINALITY: Although much has been written on architectural experiences, there is seldom written in an academic context about digital UX in space. There are some papers that consider digital as a tool for placemaking, but the literature does not delve into interaction design. Global CRE professionals that have experience of the work within this paper have praised the author for how well the systems perform and that it is a first-time experience for them.

5.9. Smart Thinking, Collection of Podcasts

Between June 2018 and January 2019, Marson recorded a set of 30 podcasts with the aim of capturing insight that was not forthcoming in conventional research contexts. The formality of the process of academic research includes a reflection and critical review. In contrast to academia, businesses cannot afford (due to time pressures) to formally record their experiments with technologies. As such, a whole body of work within the world of architecture was not being captured/recorded. Marson created the Smart Thinking podcast series as a direct consequence to formally capture, in a modern and marketable communication style, interviews between the author and other industry leaders. Marson recorded a vast array of topics in which he was able to speak with global thought leaders about their respective expertise – this included the Director of Transformation at facility manager, Mitie, the Head of Smart Cities at Siemens, a Proposition Designer at the Deloitte owned agency, Market Gravity, and range of leaders at global engineering and design consultancy WSP – to name a handful of roles.

As a source of primary research, the podcasts synthesised notable case studies, facts and learnings from real-world experimentation and technology implementations, and personal experiences. The conversational nature of the podcasts gives a candid, rather than sales-led or overly-analytical, analysis of the efforts of technologists, engineers and architects to an emerging epoch of architecture. Prevalent throughout all the conversations was the need for a common definition of smart buildings and the importance of well-defined design intent.

Editorially, Marson crafted a body of work that aims to set the scene for a complete novice to the field and gradually increased the complexity of the content as the audience began to become more familiar with the concepts covered. The author aimed to balance conversations about specific technologies (such as platforms or HVAC[12] analytics), the nuances for certain building typologies (such as stadia or health) in which they are applied and their impacts on the design (such as holistic engineering, architecture or cities).

[12] Heating, Ventilation and Air Conditioning

As a body of work, the podcasts captured the evolving tone and value levers presented in this commentary as well as the technologies and experience involved in the design of smart buildings and smart cities. The podcasts served to reflect on the learnings of technological advancements in smart buildings and their societal implications (§7).

The podcasts were published in a weekly series, starting in October 2018 and finishing in May 2019. There were several thousand unique listens receiving written engagement from subscribers. A list of the podcasts is presented in Appendix A and the full transcripts are presented in the body of work.

5.10 A Cohesive Body

This research captures the zeitgeist of key developments in the smart buildings field as a natural product of their 'moment in time'. As such, the chronological development demonstrates how technologies and their associated value levers have evolved over time. As academic and industrial research focus shifted, so did this work. This commentary will propose a model in which different generations of smart buildings can be assessed against.

Together, these works represent a compendium of original contributions to wider knowledge. Firstly, the way in which the works define a smart building through real-world examples offers a solution to the very poorly defined and multiple conflicting definitions in industry and academia. Secondly, the works capture the evolving nature of emerging technologies and industrial trends that are typically poorly documented, and subsequently rationalised. Thirdly, the current literature on smart buildings typically documents technical systems' architectures and is usually only thorough in quantifying the impact of the first generation of smart buildings in terms of energy conservation; this portfolio extents this by translating those successes into business imperatives. Finally, and most importantly, Marson has devised, evaluated, and applied the technologies and methods described in the papers in an industrial context. Some represent first-of-a-kind proof of concepts and implementations. The development of these frameworks has served as repeatable and standardised parts of subsequent projects.

6. A Model for the Evolution of Smart Buildings

As a further demonstration of these papers as a cohesive body, the below presented model demonstrates the role of the research contributions in portraying the evolution of smart buildings.

Over the course of the last decade, Marson's career has been concerned with the development and delivery of smart buildings. Throughout the research and industrial experiences, it has become evident that the reason for a client to want a smart building has changed over time.

As a result, this paper proposes an integrated model (Figure 1) that describes the evolution of pertinent smart buildings' value levers over time:

1. **Sustainability** – technology that uses data and sophisticated controls to reduce energy and water consumption and to extend the lives of assets.
2. **Space** – technology that uses data to demonstrate space usage that provides insight on the usage of spaces/facilities, traffic and routes, and adapts to different people.
3. **Sapiens** – technology that uses data to demonstrate an improvement in health and well-being, productivity and experience.

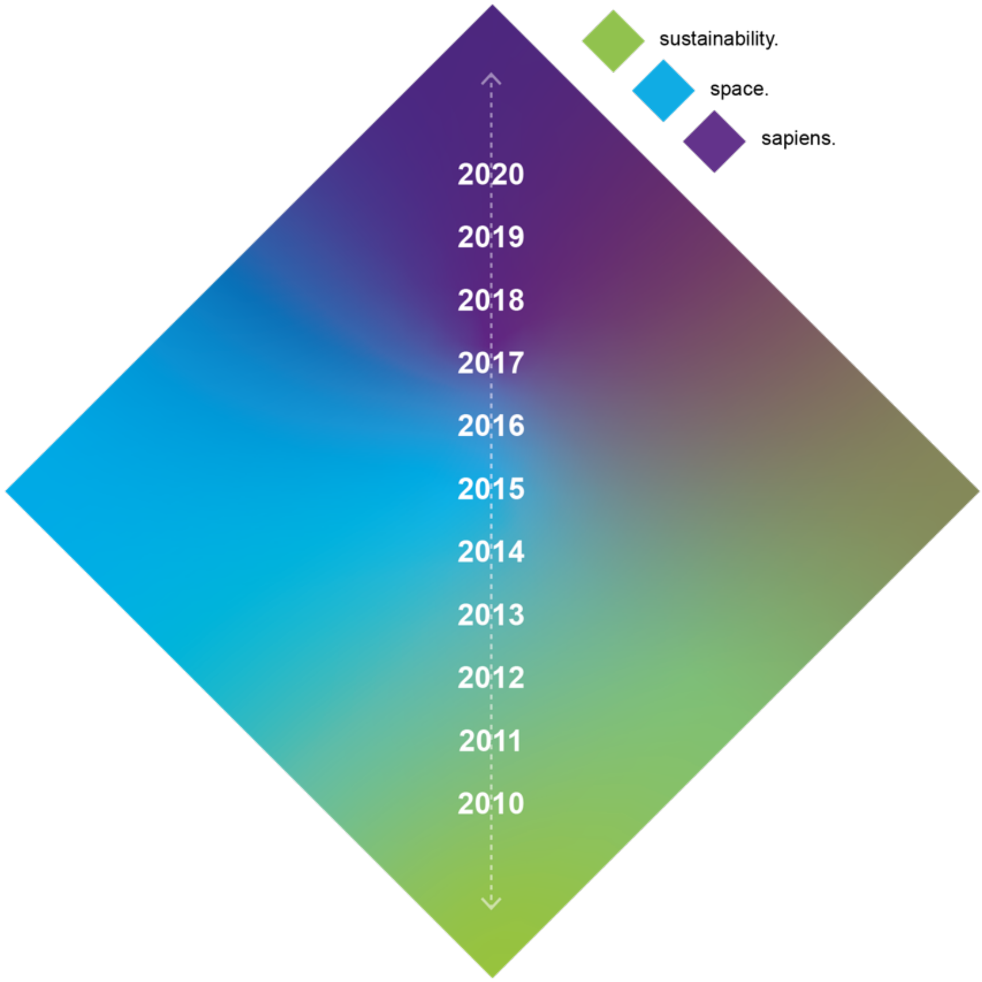


Figure 1: The Marson Model for the Evolution of Smart Buildings.

Tracking the prominent smart building value lever by year

Figure 2: Works in this paper (indicated by number) mapped against the Marson Model for the Evolution of Smart Buildings.

This figure is to support the reader of this commentary to understand the chronological significance of the papers/contributions to this thesis.

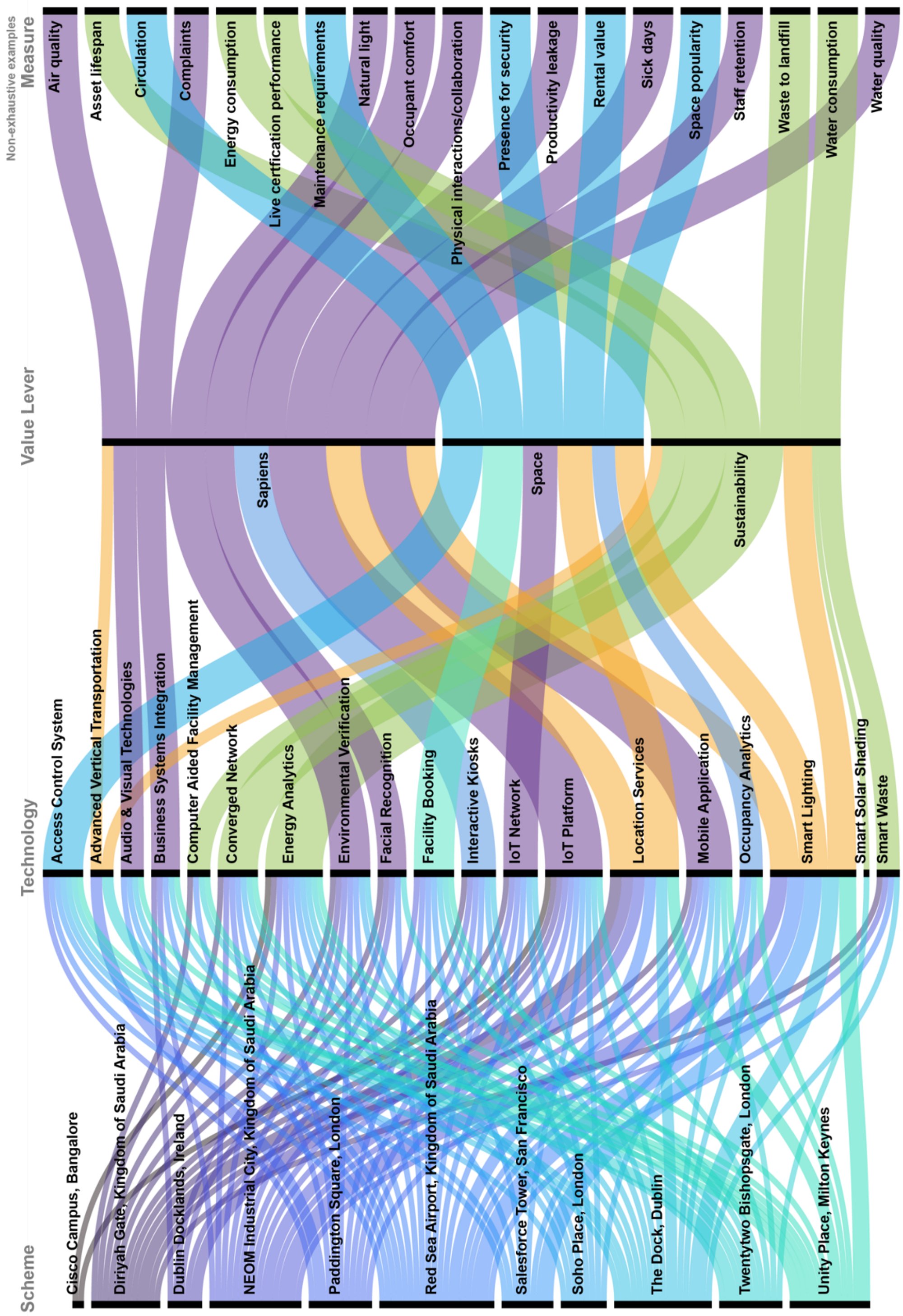


Figure 3: Marson’s Smart Building Technology and Value Lever Map

This figure demonstrates how the most common smart building technologies contribute to the value levers of sustainability, space and sapiens. The technologies are mapped to the schemes that the author has contributed to in order to give context as to the scale, applicability and significance the technology *has towards the value levers. Non-exhaustive, illustrative measures have been provided to provide further context to the drivers behind the schemes.*

6.1 Sustainability

During the early noughties, many organisations were reaching maturity for their first wave of sustainable interventions. Mostly, this was done under the banner of Corporate Social Responsibility. During the early 2010s, smart building deployments were almost exclusively centred around cost reduction (Brown, K., et al., 2016), through the guise of sustainability. As a hang-over to the pressures of the 2008 financial crisis, organisations were looking for ways to reduce their operational expenditure.

The Building Management System (BMS) is responsible for the operations of 40% of the energy consumption of a building (Clements-Croome, 2014). As such, the often-under-utilised data that is generated could be employed to find a set of low or no capital expenditure energy conservation measures. As an existing source of measurement, data acquisition is lower-cost and higher-yielding for application in energy consumption reduction against other methods which require new sensors to be added.

Furthermore, as trend forecast techniques and simple machine learning techniques were being developed, the BMS was an easy target to support facility managers in reducing their need for schedule-based equipment maintenance. HVAC analytics allowed them to move to data-predicted maintenance. As a consequence, organisations reported that the lifespan of their assets were also increasing. At the Bangalore campus of Cisco alone, the author's HVAC analytics deployment identified $10 million of energy savings through control system tweaks (§5.2).

In order to remain relevant in the market, many BMS creators and Original Equipment Manufacturers (OEMs) have changed their products to support open protocols and data visualisation. Some have rudimentary forecasting tools built in. Data acquisition still remains a challenge and towards the end of the 2010s, new standards began to emerge to combat the challenges (captured in Marson, M., Kinch, J., 2020, §5.7).

6.2 Space

During the middle part of the 2010s, the focus for smart buildings was one of space optimisation. With increasing rents in most metropolitan areas, the focus of corporate real estate departments, regardless of sector, was to remove expense from the business (Smith, 2019).

To support this mission, workplaces were looking for greater flexibility in their designs (Stoddart, 2016). The simple architectural design tactics (Stoddart, 2016) which were taken by organisations led to workplaces adopting high desk sharing ratios that forced employees to work more from home. Over the course of the decade, the average space allocation for an employee in commercial property in Europe was around 23 metres squared per full time employee. By the end of the decade, the space allocation was closer to 10 metres squared per full time employee (HM Government Property Services, 2015). Most famously, WeWork were able to run at a space allocation of 6 metres squared per full time employee equivalent (Russell, 2018). The coronavirus pandemic is likely to have altered the forward-looking market demand on this level of space allocation.

In order to deliver these sorts of efficiencies, it became necessary to invent new ways of designing the workplace. The low space allocations led to the proliferation of activity-based working. Activity-based working offers the employee the ability to select a suitable work setting for the tasks that they are performing. In essence, it means that there are no assigned desks. The employee is expected to move around their workspace during the day and select furniture and equipment on the basis of what they need to do (Stoddart, 2016). To take advantages of collaboration spaces, focus pods and open working benches, all whilst balancing capacity, it is necessary to utilise smart buildings technology. Digital more broadly, has brought on the fundamental changes to working styles, from focused, repeatable tasks to knowledge-based collaboration. As a consequence of these new space requirements, architectural design alone does not allow for successful management of flexible spaces - the demand for smart buildings technologies has continued to rise to support the need. Being able to manage the complexity of operating spaces without person-assigned locations, means that sensing tools and software may be needed to facilitate high occupancy levels with the availability of places to work (Biswas, A., 2019).

6.3 Sapiens

Towards the end of the 2010s, digital combined with prolific connectivity had led to an ‘always on culture’, meaning that employees’ productivity had now plateaued. Given the advances in the tools that were made available to employees alongside new ways of working, people were experiencing burnout. This feeling was exacerbated by an expectation to always be connected, leading to a poor work-life balance (Fjord, 2018). To help counteract this, organisations responded by delivering workplaces with a high focus on human impact - the architectural design interventions would use health and well-being as a proxy for increasing employee productivity.

Organisations started to measure volatile organic compounds (VOCs such as formaldehyde, styrene, limonene, etc.), air pollutants (e.g., NOx, $PM_{2.5}$, etc), carbon dioxide (CO_2), compounds in water and natural lighting as a way of demonstrating the quality of the space provided (International Well Building Institute, 2016). The impact of this data shown from these smart buildings' initiatives have given architects a renewed motivation in closing the performance gap of their design, not just in energy performance, but also in health performance.

In the latter part of the 2010s (2016 onwards), workplaces were often cited as the battleground for the war on talent, as organisations struggled to find digital natives[13] that could continue to support the business on its use of tools to increase productivity. There are notable examples from Google, Facebook and Twitter for the sorts of ludic workplaces that they were, and are still, offering, as a way to attract and retain the very best talent (Accenture, 2017).

Many consulting practices created employee experience offerings to respond to the market demand and societal shift. UX, in particular, was a new field. The smart buildings technology market growing from $34.8Bn in 2017 to a projected $84.2Bn by the end of the decade (Memoori, 2018). This 19.4% compound annual growth rate suggests a vast increase in the number of existing companies and the emergence of new ones, all with the goal of tackling human outcomes.

[13] People born into or brought up during the era of digital technology, having familiarity with computers and the internet from an early age

Notably, interactive kiosks and mobile applications were seen as a way to deliver exciting, interactive and digital-first architectural experiences. The final paper considers the limited success of these UX projects (§5.8). Notably, research being concluded at the time of writing, IEA EBC Annex 79: Occupant-centric building design and operation (O'Brien, W., et al., 2020), considers a contemporary set of methods, requirements, and applications for ensuring occupant preference as a result of presence. Although different to UX, it is a fundamental form of user experience.

Research from the International Well Building Institute demonstrated that the typical operating costs of most commercial buildings are proportioned as 1% energy, 9% rent and 90% staff costs (International Well Building Institute, 2016). JLL went a step further and assigned a monetary value to these proportions and proposed that the average cost distribution for a commercial building per square foot per annum is $3 for utilities, $30 for rent and $300 for payroll (Construction Review Online, 2020). Both of these models support the substantiation, contained in the essence of my published works, of the three value levers – sustainability, space and sapiens.

6.4 Typologies

This commentary has focused on the workplace as a tangible and highly relatable typology to give demonstrable examples that explain the model presented. Workplaces also benefit the most clearly of all three of the value levers. The model remains applicable to other typologies of spaces.

For example, in stadia, energy saving, and the associated public messaging of being sustainable, remains at the forefront of those that operate these spaces. Space management is prevalent to ensure the greatest monetisation of parking facilities, foot-traffic to retail outlets and the queue management of the toilet facilities. Experiential (sapiens) outcomes such as virtual reality (like the experiences delivered by the Golden State Warriors), or VenueNext's snack to my seat – all require smart buildings technologies to meet our expectations of a digital experience in a physical building.

Finally, in healthcare, energy reduction and asset life span are key concerns of operators – as is the maximisation of space within existing assets. Finally, clinical outcomes such as reduced stay-time can be improved through better air quality, additional blue light (linked to circadian rhythms), tracking of patients, ability to locate specialists and equipment (such as finding a cardiologist or defibrillator in critical moments) (Rome, N., et al., 2019), all need smart building technology as a backbone.

For the purposes of brevity in this commentary, the examples and associated discussions have been truncated.

6.5 Scale

Finally, the model still holds when considering the differences in architectural scale. The technology needs for buildings are often the same for those in a city. Discussed in The Misleading Simplicity of a Smart City, the paper demonstrated how a physical/digital framework for delivering a smart place works at both scales (§5.8). The outcome of making people healthier in both a building and a city uses the same technologies to measure and respond to the challenge. It is only the tactics taken by a team that differ, which is beyond the scope of the system.

Where the scale does differ is in the impact of the outcomes. Buildings can only impact a limited population (its stakeholders). A city (as demonstrated in §5.2) has demographic-level impact.

The sustainability, space and sapiens model has been successful in the author's professional consulting engagements regardless of scale – it is able to frame the core outcomes and the necessary design responses to a variety of contexts.

7. Conclusion

Despite being a collection of discrete works, researched at different times across the last decade, together they capture an industrial perspective of the development of smart buildings in the 2010s. Using the date-stamps of the works, it is clear to see how the convergence of cheaper cloud computing and cheaper sensors (such as temperature, humidity, presence detection, etc.) have allowed architects to data-enable their designs for outcomes in sustainability, space and for sapiens. Considering this material as part of the PhD by Published Work process, the author's contribution to architecture has gathered momentum in the market, with smart buildings and cities swiftly becoming the norm in client procurement. The Dock, Dublin was an important step-change to the norm – it demonstrated the art of the possible for IoT in architecture and served as an evangelical tool to convince others of the business and experiential benefit of investment in technology.

To assess the aims and objectives of this commentary (§2.3):

Aim	**Evidence of Achievement**
1. To reflect on the author's previous publications as a coherent body of work that contributes to the advancement of the built environment disciplines	§5 defines the author's academic contributions, key research gaps, findings and originality that has advanced the built environment.
2. To define the value of a smart building	The Marson Model defines the three primary value levers that a smart

	building creates (sustainability, space and sapiens) as captured during the development of the research contained in this thesis.
3. To capture the key trends and technologies that make a smart building	The amalgamation of the papers into a single, coherent thesis chronologically documents the key trends and technologies that make a smart building.

Objective	**Evidence of Achievement**
1. To demonstrate and evidence the changes, over time, of the primary functionality of a smart building	The chronology of publishing demonstrates how the early 2010s focused on sustainability, the mid-decade on space and the end of the decade on sapien-related functionality.
2. To evidence the wide range of industrial contributions to academic research in the smart buildings field;	The equal contributions of both industrial (47%), academic (52%) and other (1%) literature evidence the important developments contributed outside of academia
3. To propose a model for the evolution of the primary driver for creating a smart building in the 2010s	Figure 1 is a model proposed to show evolution, over time, of the primary driver for creating a smart building.

7.1 Methodology

A commentary as part of a PhD by Published Work provides an opportunity to reflect on the past research and situate it in a context for preparing an academic discord. This method is limited in that it focuses on the work of the author and does not provide the opportunity to embed new research. It does, however, allow for a new rationalisation on previously peer reviewed and published work, enhancing the value of existing contributions.

7.2 Main Findings

- Demonstrated by publication date-stamp and the literature referenced, the early years of the 2010s was focused on how smart buildings could impact sustainability;
- Growing concerns of rental costs then led technology in the built environment to be applied to the management and therefore reduction of space in commercial contexts during the middle of the 2010s;
- Towards the end of the 2010s, industry applied IoT/smart buildings technologies towards outcomes that benefited sapiens (health and well-being, productivity, etc);
- Market drivers, rather than technological advancement, have shaped the evolution of smart places.

7.3 Research Limitations

This research was limited, primarily, by the lack of previous studies into this field. Furthermore, the sample of buildings, cities and case studies could provide bias as they represent the work of the author. A library of assessed smart buildings and cities would allow researchers in the future to a consistent foundation for analysis.

7.4 Future Work

To develop this research and contribute to the academic body of knowledge further, the author plans to develop a standard/common language in which smart buildings and cities and be discussed and therefore objectively assessed. Additionally, a study into the impact of COVID on rapid digitalisation of our buildings would be a worthy topic of study.

7.5 Final Remarks

Smart building technologies allow for the acquisition and analysis of data that were previously dormant in a building. Being able to understand the complexities of Building Management Systems against real-time space utilisation allows an architect to design a space that is adaptable and prioritises sustainability outcomes without the detriment to the user. Advanced control systems such as interactive kiosks and mobile applications have led to a step-change in experiential outcomes. Users are now empowered to modify their environment and engage with others socially to perform compliance tasks (such as physical security checks) with little to no interaction. Combined, IoT technologies have allowed businesses to analyse and alter the use of their built environment assets to reduce expenditure and increase employee engagement – providing strategic value and not just a necessary cost to the business (Centre for Digital Built Britain and Digital Framework Task Group, 2018).

8. Glossary

Terms used within this commentary:

Term	Expansion/Explanation
Value lever	A set of actions, methods or technologies that can be employed to realise outcomes that align to a common purpose.
Value chain	The parties, methods and technologies that together, form end-to-end processes.
Point solution	A technology that addresses only 1 problem or issue.
Proprietary	Technologies that are owned by a party and are therefore closely controlled. Antonym: open source.

Terms used within the collection of works and the commentary:

Term	Expansion/Explanation
ACS	Access Control System
Apache Jena	Open source web framework for Java. Extracting and writing data to and from RDF graphs using an API.
API	Application Programming Interface
API	Application Programming Interface
AR / VR	Augmented Reality and Virtual Reality
AV	Audio Visual
BACnet	Building Automation and Control network
BEMS	Building Energy Management System
BIC	Baggage Input Console

BIM	Building Information Modelling
BMS	Building Management System
Brick Model/Schema	A uniform metadata schema for buildings. Brick is used as a representation of different resources in buildings and their systems. Brick models the building components using tags and describes the set of relationships and how they interact.
CAD	Computer Aided Design
CAFM	Computer Aided Facilities Management
CCTV	Closed-Circuit Television
CMS	Content Management System
CoAP	Constrained Application Protocol is an IoT protocol designed for constrained devices and constrained networks used in M2M data exchange such as smart energy and building automation.
CoV	Change of Value
DALI	Digital Addressable Lighting Interface
EAI	Enterprise Application Integration
Edge Device	An edge device is a type of networking device that connects external wide area network with internal local network within the enterprise
FAS	Fire Alarm System
FAT	Factory Acceptance Testing
FM	Facilities Manager
FMS	Facilities Management System
Gateway	A gateway is a network node that connects two networks that use different protocols together. It provides

	communication to a remote network that is out of bounds for the host network nodes.
GDPR	General Data Protection Regulation
GIS	Geographic Information System
GUI	Graphical User Interface
HTTP	HyperText Transfer Protocol is a widely used protocol and adopted over the internet. It is a set of standards and rules that defines the request/response model for exchanging information on the web.
HTTPS	Protocol that uses HTTP over a connection that is encrypted by Transport Layer Security (TLS)
HVAC	Heating Ventilation and Air Conditioning
iBMS	Integrated Building Management System
ICT	Information and Communication Technology
Interface Segregation	Many client-specific interfaces are better than one general-purpose interface
Interoperability	Characteristic of a product or system, whose interfaces are completely understood, to work with other products or systems, at present or in the future, in either implementation or access, without any restrictions.
IoT	Internet of Things
IP	Internet Protocol
ISMS	Information Security Management System
JSON	JavaScript Object Notation
KNX	Open communications standard for commercial and domestic building automation.

LCS	Lighting Control System
MEP	Mechanical, Electrical & Plumbing
MQTT	MQTT is a M2M / IoT connectivity protocol. It is lightweight and design for low bandwidth environment. It provides resource-constrained network clients with a simple way to distribute information.
MSI	Master System Integrator
MUD	Manufacturer Usage Description
MVC	Model, View and Controller
NMS	Network Management Services
Object Model	A logical interface, software or system that is modelled through the use of object-oriented techniques. It enables the creation of an architectural software or system model prior to development or programming
OEM	Original Equipment Manufacturer
OPC	Open Platform Communications
Open-Closed	Software entities should be open for extension, but closed for modification
PaaS	Platforms as a Service
QoS	Quality of Service
REST	Representational State Transfer. It is a web-service paradigm that provides standards between computer systems on the web and allows for intercommunication of these systems on the internet.
RMS	Resource Management System
SACS	Security and Access Control System

SAT	Site Acceptance Testing
SDKs	Software Development Kits
Tagset	Representing different entities within a building. These are then broken down into subclasses of tags.
TCP	Transmission Control Protocol
TLS	Transport Layer Security. It is a cryptographic protocol designed to provide secure communication over networks especially for internet communications. It is a widely adopted security protocol that facilitates privacy and data security between web applications and servers.
URL	Uniform Resource Locator
VLAN	Virtual Local Area Network
VT	Vertical Transportation

9. Published Works

9.1 Reports

Brown, K., et al., 2016. *Environmental Sustainability Principles for the Real Estate Industry*, Davos: World Economic Forum.

Clements-Croome, D., Marson, M. & Yang, T., 2018. *Research Roadmap for Intelligent and Responsive Buildings*, Amsterdam: International Council for Research and Innovation in Building and Construction.

Clements-Croome, D., Marson, M. & Yang, T., 2018. *The Journey Towards Creating Intelligent Buildings*, Amsterdam: International Council for Research and Innovation in Building and Construction.

9.2 Journal Papers

Marson, M., 2018. *The Business Value of an Innovative Building*. Corporate Real Estate Journal, 8(2), pp. 154-164.

Marson, M. & Kinch, J., 2020. *The Challenges of Retrofitting Smart Systems Into Existing Buildings*. Royal Institute of Chartered Surveyors Journal.

Marson, M. & Goncharov, K., 2020. *The Misleading Simplicity of Smart Cities*. Intelligent Buildings International, 13(3), pp. 176-186.

Marson, M. & McAllister, J., 2020. *The Human Connection to an Intelligent Building*. Intelligent Buildings International, 13(3), pp. 162-175.

9.3 Book Chapters

Yang, T., Clements-Croome, D. & Marson, M., 2017. *Building Energy Management Systems*. In: M. A. Abraham, ed. Encyclopaedia of Sustainable Technologies. London: Elsevier, pp. 291-309.

Clements-Croome, D., Marson, M. & Yang, T., 2017. *Planning and Design Scenarios for Liveable Cities*. In: M. A. Abraham, ed. Encyclopaedia of Sustainable Technologies. London: Elsevier, pp. 81-97.

9.4 Research Podcasts

Marson, M., 2019. Smart Thinking: 1 - What is a Smart Building? [Interview] (14 March 2019).

Marson, M., et al., 2019. Smart Thinking: 2 - The Value of Smart Building [Interview] (21 March 2019).

Marson, M., 2019. Smart Thinking: 3 - Why Smart Buildings are Difficult [Interview] (28 March 2019).

Marson, M., Moazami, K., 2019. Smart Thinking: 4 - Smart and Holistic Engineering [Interview] (4 April 2019).

Marson, M., Offer, N., 2019. Smart Thinking: 5 - The Digital Transformation of Engineering [Interview] (11 April 2019).

Marson, M., Hollis, T., 2019. Smart Thinking: 6 - Digital Services & Service Design [Interview] (18 April 2019).

Marson, M., Patel, M., 2019. Smart Thinking: 7 - HVAC Analytics [Interview] (25 April 2019).

Marson, M., Wrattan, J., 2019. Smart Thinking: 8 - Smart Lighting [Interview] (2 May 2019).

Marson, M., Biswas, A., 2019. Smart Thinking: 9 - Smart for Operations [Interview] (9 May 2019).

Marson, M., Sossa, M., 2019. Smart Thinking: 10 - Human Centred Design [Interview] (16 May 2019).

Marson, M., Rome, N., Cassidy, K., 2019. Smart Thinking: 11 - Smart Healthcare [Interview] (23 May 2019).

Marson, M., Jarvis, S., 2019. Smart Thinking: 12 - Measuring Productivity [Interview] (30 May 2019).

Marson, M., Hogan, E., 2019. Smart Thinking: 13 - Location Services [Interview] (6 June 2019).

Marson, M., Knibb, H., 2019. Smart Thinking: 14 - Digital Wellness [Interview] (13 June 2019).

Marson, M., Clarke, C., 2019. Smart Thinking: 15 - Ethics [Interview] (20 June 2019).

Marson, M., Smith, T., 2019. Smart Thinking: 16 - Drivers for Strategic Value [Interview] (27 June 2019).

Marson, M., Wrattan, J., 2019. Smart Thinking: 17 - New Business Models for Developers [Interview] (4 July 2019).

Marson, M., Richards, P., 2019. Smart Thinking: 18 - Security [Interview] (11 July 2019).

Marson, M., Brittle, M., 2019. Smart Thinking: 19 - Access Control [Interview] (18 July 2019).

Marson, M., Russel, P., 2019. Smart Thinking: 20 - Platforms [Interview] (25 July 2019).

Marson, M., Chatupt, C., 2019. Smart Thinking: 21 - APIs/AI [Interview] (1 August 2019).

Marson, M., Okraglik, H., 2019. Smart Thinking: 22 - Appification [Interview] (8 August 2019).

Marson, M., Jones, J., McDermott, P., 2019. Smart Thinking: 23 - Blockchain [Interview] (15 August 2019).

Marson, M., Alexander, J., 2019. Smart Thinking: 24 - Smart Cities [Interview] (22 August 2019).

Marson, M., Singh, R., 2019. Smart Thinking: 25 - Converged Network [Interview] (29 August 2019).

Hammer, N., Marson, M., Wrattan, J., 2019. Smart Thinking: 26 - Smart Stadia [Interview] (5 September 2019).

Marson, M., Todd, G., 2019. Smart Thinking: 27 - Middle East Striving for Smart Success [Interview] (12 September 2019).

Hammer, N., Marson, M., Els, H., 2019. Smart Thinking: 28 - Global smart Workplace Strategy Project [Interview] (19 September 2019).

Marson, M., Salam, D., 2019. Smart Thinking: 29 - Smart Design [Interview] (26 September 2019).

Marson, M., et al., 2019. Smart Thinking: 30 - Round Up [Interview] (3 October 2019).

9.5 Conferences (not for assessment)

Marson, M., 2020. Answering the Big Questions with Data Analytics. In: Smart Buildings Show. London: Smart Buildings Magazine.

Marson, M., 2020. How digital can enable the 'new normal' in the Workplace. In: Refitting with Retrobytes. Munich: Schneider Electric.

Marson, M., 2020. Fourth Industrial Revolution. In: CIBSE Webinar. London: CIBSE.

Marson, M., 2020. Future-proof your workspace. In: Global PropTech Conference. Amsterdam: Global PropTech.

Marson, M., 2020. Smart Workplace. In: ISE. Amsterdam: ISE.

Marson, M., 2020. 5 Things I've Learnt from Getting Smart Wrong. In: Smart Buildings Conference: London. Smart Buildings Conference.

Marson, M., 2019. 5 Things I've Learnt from Getting Smart Wrong. In: Smart City World Expo. Barcelona: Fira.

Marson, M., 2019. 5 Things I've Learnt from Getting Smart Wrong. In: Smart Buildings Show: Smart Buildings Magazine.

Marson, M., 2019. Smart Buildings. In: LEAF International. Berlin: LEAF International.

Marson, M., 2019. 5 Things I've Learnt from Getting Smart Wrong. In: Smart Buildings Kick-Off. UK: BRE.

Marson, M., 2019. The Business Value of an Innovative Building. In: Construction Industry Council Conference. Hong Kong: Construction Industry Council Hong Kong.

Marson, M., 2019. Roadmap Towards Intelligent Buildings. In: CIB World Congress. Hong Kong: CIB.

Marson, M., 2019. Digital Twins. In: IB Con. Nashville: RealComm.

Marson, M., 2019. Smart Building Infrastructure. In: IB Con. Nashville: RealComm.

Marson, M., 2019. 5 Things I've Learnt from Getting Smart Wrong. In: Smart Buildings 19. London: WorkTech.

Marson, M., 2018. Smart Buildings. In: LuxLive. London: LuxLive.

Marson, M., 2018. Smart Buildings. In: CIO Briefings. London: RealComm.

Marson, M., 2018. The Business Value of an Innovative Building. In: WorkTech. Munich: WorkTech.

Marson, M., 2018. The Business Value of an Innovative Building. In: Smart Buildings 18. London: WorkTech.

Marson, M., 2017. The Workplace of the Future. In: WorkTech. London: WorkTech.

Marson, M., 2017. WhyOT, Reasons You Need a Connected Building. In: Smart Buildings Show. London: Smart Buildings Magazine.

Marson, M., 2017. The Workplace of the Future. In: IoT World Congress. Barcelona: Fira.

Marson, M., 2017. Smart Cities. In: ConneXions. Dublin: French Government.

Marson, M., 2017. The Workplace of the Future. In: Future Financial. London: WorkTech.

Marson, M., 2017. Ultra Keynote. In: Nordic Smart Buildings Conference. Helsinki: Nordic Smart Buildings Conference.

Marson, M., 2016. HVAC Analytics. In: IoT World Congress. Barcelona: Fira.

Marson, M., 2016. Smart Buildings. In: Smart Buildings Conference. Amsterdam: Smart Buildings Conference.

9.6 Buildings & Cities Featuring Application of My Research (not for assessment)

Completed Buildings	Buildings Under Construction (as of January 2021)	City Masterplans
Twentytwo Bishopsgate, London	Soho Place, London	Dublin Docklands, Ireland
The Dock, Dublin	Paddington Square, London (Renzo Piano Buildings Workshop)	NEOM Industrial City, Kingdom of Saudi Arabia (Bjarke Ingles Group)
Cisco Campus, Bangalore	Red Sea Airport, Kingdom of Saudi Arabia (Foster + Partners)	Diriyah Gate, Kingdom of Saudi Arabia
Morgan Stanley Portfolio	Unity Place, Milton Keynes (LOM)	University of Glasgow Campus
Greystar Portfolio	The Featherstone Building, London	The Crown Estate, Regional Portfolio
14^{th} @ Irving, New York		
Salesforce Tower, San Francisco		

9.7 Industry Press Coverage & Awards (for context, not assessment)

22 Bishopsgate Official Brochure (named)

Archi Expo Magazine

BISRIA

Buildings Magazine

Buildings Magazine Digital Leader

CIB Future Leaders

CIO Applications Europe

Edited and contributed to The Possible

Engineering Council News

IMechE Young Visionary

IoT World Congress Awards Finalist

LEDs Magazine

Specifier Magazine

Tall Building Conference

University Business

WorkTech Academy

10. References

2001: A Space Odyssey. 1968. [Film] Directed by Stanley Kubrick. UK: Metro-Goldwyn-Mayer.

Bernstein, E., 2020. Getting Smart About Smart Buildings. *MIT Sloan Management Review,* 62(1), pp. 11-13.

Bougdah, H. & Sharples, S., 2010. *Environment, Technology and Sustainability.* 1 ed. London: Taylor & Francis.

Breuer, M., 1934. *Buildings and Projects.* Zurich: s.n.

Brown, K., Marson, M. & Ellisson, L., 2016. *Environmental Sustainability Principles for the Real Estate Industry,* Davos: World Economic Forum.

Buckman, A., Mayfield, M. & Beck, S., 2014. What Is a Smart Buildings?. *Smart and Sustainable Built Environment,* 3(2), pp. 92-109.

Centre for Digital Built Britain and Digital Framework Task Group, 2018. *The Gemini Principles,* Cambridge: BIES.

Clarke, C., 2019. *Smart Thinking: Ethics* [Interview] 2019.

Clegg, P., 2017. *2017 Soft Landings Conference: Delivering Value through Soft Landings.* London: BSRIA.

Clements-Croome, D., 2014. *Intelligent Buildings An Introduction.* 1 ed. Oxford: Routledge.

Clements-Croome, D., Marson, M. & Yang, T., 2017. Planning and Design Scenarios for Liveable Cities. In: M. A. Abraham, ed. *Encyclopedia of Sustainable Technologies.* London: Elsevier, pp. 81-97.

Clements-Croome, D., Marson, M. & Yang, T., 2018. *Research Roadmap for Intelligent and Responsive Buildings,* Amsterdam: International Council for Research and Innovation in Building and Construction.

Clements-Croome, D., Marson, M. & Yang, T., 2018. *The Journey Towards Creating Intelligent Buildings,* Amsterdam: International Council for Research and Innovation in Building and Construction .

Construction Review Online, 2020. *The 3-30-300 Rule, Understanding The Real Operating Cost Of Buildings.* [Online]
Available at: https://constructionreviewonline.com/2020/09/the-3-30-300-rule-understanding-the-real-operating-cost-of-buildings/
[Accessed 10 November 2020].

Fjord, 2018. *Physical Fights Back.* [Online]
Available at: https://trends18.fjordnet.com/physical-fights-back/
[Accessed 28 December 2020].

Fjord, 2018. *Trends 2018,* London: Accenture.

Frampton, K., 2007. *Modern Architecture A Critical History.* 4 ed. London: Thames & Hudson.

Gartner, 2017. *Forecast Analysis: Internet of Things — Endpoints, Worldwide, 2016 Update,* New York: Gartner.

Gartner, 2019. *Forecast: Public Cloud Services, Worldwide, 2017-2023, 3Q19 Update,* 2019: Gartner.

Gropius, W., 1964. *Architecture and the Computer.* Boston, Boston Architectural Center.

HM Government Property Services, 2015. *Employment Density Guide,* London: GM Government.

International Well Building Institute, 2016. *WELL Building Standard,* Ney Work: Delos Living LLC.

IPCC, 2007. *Zero Carbon Britain,* London: CAT.

Kane, G. C., Palmer, D., Philips, A. N. & Kiron, D., 2017. Winning the Digital War Talent. *Harvard Business Review.*

Le Corbusier, 1930. *Precisions on the Present State of Architecture and City Planning.* Zurich: MIT Press.

Le Corbusier, 2008. *Toward an Architecture.* London: Frances Lincol Limited.

Leesman, 2018. *Leesman: Measuring your employee experience.* [Online] Available at: https://www.leesmanindex.com/
[Accessed 29 December 2020].

Licklider, J. C. R., 1960. Man-Computer Symbiosis. *IRE Transactions on Human Factors in Electronics,* Issue 1, pp. 4-11.

Marson, M., 2018. The business value of an innovative building. *Corporate Real Estate Journal,* 8(2), pp. 154-164.

Marson, M. & Goncharov, K., 2020. The Misleading Simplicity of Smart Cities. *Intelligent Buildings International.*

Marson, M. & Kinch, J., 2020. The Challenges Of Retrofitting Smart Systems Into Existing Buildings. *Royal Institue of Chartered Surveyors Journal.*

Marson, M. & McAllister, J., 2020. The Human Connection to an Intelligent Building. *Intelligent Buildings International.*

Maslow, A., 1943. A theory of Human Motivation. *Psychological Review,* 50(4), pp. 370-396.

McKinsey & Company, 2019. *Growing opportunities in the Internet of Things,* San Francisco: McKinsey & Company.

Memoori, 2018. *IoT in Smart Buildings,* Stockholm: Memoori.

Negroponte, N., 1972. *The Architecture Machine.* 2 ed. Cambridge, MA: MIT Press.

Nguyen, T. A. & Aiello, M., 2013. Energy Intelligent Buildings Based on User Activity: A Survey. *Energy and Buildings,* January, Issue 56, pp. 244-257.

Okraglik, H., 2019. *Smart Thinking: Appification* [Interview] (8 August 2019).

Pelsmakers, S., 2012. *The Environmental Design Pocketbook.* 1 ed. London: RIBA Publishing.

Reyner, B., 1984. *The Architecture of the Well-Tempered Environment.* Chicago, Elsevier.

RIBA, 2020. *The Way Ahead,* London: RIBA.

Russell, P., 2018. *IBM Business to Business with WSP* [Interview] (July 2018).

Salam, D., 2019. Smart Thinking: 29 - Smart Design [Interview] (26 September 2019).

Skyscraper. 2018. [Film] Directed by Rawson Marshall Thurber. USA: Legendary Entertainment.

Smith, N. J., Merna, T. & Jobling, P., 2014. *Managing Risk in Construction Projects.* 3 ed. London: Wiley & Sons.

Smith, T., 2019. *Smart Thinking: Drivers for Strategic Value* [Interview] 2019.

Smith, T., 2019. *Smart Thinking: Drivers for Strategic Value.* [Sound Recording] (WSP).

Steenson, M. W., 2017. *Architectural Intelligence: How Designers and Architects Created the Digital Landscape.* Cambridge, Massachusetts: MIT Press.

Stimmel, C. L., 2015. *Building Smart Cities: Analytics, ICT and Design Thinking.* London: Auerbach Publications.

Stoddart, C., 2016. *The Workplace Advantage.* 1 ed. London: Raconteur.

The Simpsons: Treehouse of Horror XII (S13, E1). 2001. [Film] Directed by Jim Reardon. USA: 20th Centuary Fox.

Ubels, E., 2017. *The Edge.* Amsterdam, Smart Buildings Conference.

Yang, T., Clements-Croome, D. & Marson, M., 2017. Building Energy Management Systems. In: M. A. Abraham, ed. *Encyclopedia of Sustainable Technologies.* London: Elsevier, pp. 291-309.

11. Bibliography

Accenture, 2013. Defining Success: Global Research Results, London: Accenture.

Accenture, 2014a. Digital government: Pathways to delivering public services for the future. London: Accenture.

Accenture, 2014b. Towards world-class jobs and skills in Europe. London: Accenture.

Accenture, 2017. Workforce of the Future, Chicago: Accenture

Accenture, 2018. Robotics Process Automation in Banking, Insurance & Capital Markets. [Online] Available at: https://www.accenture.com/us-en/insight-financial-services-robotic-process-automation

Accenture Digital, 2017. Connected Facilities, Boston: Accenture.

Accenture Strategy, 2016. Workplace Productivity Leakage, Copenhagen: Accenture.

Airaksinen, M., 2016. Smart cities, can the performance be measured?. Finland: Otavamedia, VTT Impulse 1/2016. http://www.vttresearch.com/Impulse.

Alexander, J., 2019. Smart Thinking: Smart Cities. London: WSP.

Allen, J. G. et al., 2016. Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments, Cambridge, Massachusetts: Harvard School of Public Health.

Alwaer, H., Clements-Croome, D.J., 2010. Key performance indicators (KPIs) and priority setting in using the multi-attribute approach for assessing sustainable intelligent buildings. Building and Environment 45 (4), 799–807.

Apple, 2020. Apple Inc. Document Accessed Online: https://www.apple.com/uk/apple-pay/

Apple, 2020. Apple Inc. Document Accessed Online: https://www.apple.com/uk/watch/?afid=p238%7CsjHUjLmSy-dc_mtid_20925xua42643_pcrid_465982635782_pgrid_112714367201_&cid=wwa-uk-kwgo-watch--slid--productid--

Aquilina, O., 2006. A Brief History of Cardiac Pacing. National Center For Biometric Information. Document Accessed Online: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3232561/

Arboleya, P., Gonzalez-Moran, C., Coto, M., Falvo, M.C., Martirano, L., Sbordone, D., Bertini, I., Pietra, B.D., 2015. Efficient energy management in smart micro-grids: zero grid impact buildings. IEEE Transactions on Smart Grid 6 (2), 1055–1063.

Asare-Bediako, B., 2014. SMART energy homes and the smart grid – a framework for intelligent energy management systems for residential customers. PhD Thesis, Eindhoven University of Technology, The Netherlands.

Ayonix, 2020. Ayonix Corporation. Document Accessed Online: https://ayonix.com/

BAMB, 2019. Materials Passports- Best Practice. Document Accessed Online: https://bamb2020.eu

Barker, J., 2019. Tacking the Tower of Babel. London: British Land.

BCIA, 2016. Guide to planning your BEMS and controls. The building controls industry association (BCIA). https://bcia.co.uk/resources/ (accessed 28 August 2016).

Bernal, W., Behl, M., Nghiem, T.X., Mangharam, R., 2012. MLEþ: a tool for integrated design and deployment of energy efficient building controls. In: Proceedings of the 4th ACMnWorkshop on Embedded Sensing Systems for Energy-Efficiency in Buildings (BuildSys '12), Toronto, Canada, pp. 215–216.

Bioteq, 2020. Bioteq Limited. Document Accessed Online: https://www.bioteq.co.uk/

Biswas, A., 2019. Smart for Operations. London: WSP.

Blythe, M., Hassenzahl, M. 2003. Funology - From Useability To Enjoyment. Germany: Springer

Boyes, H., 2014. Building information modelling (BIM): addressing the cyber security issues. IET cyber security Consortium report. Institution of Engineering and Technology, London.

Braham, W.W., 2016. Architecture and system ecology – thermodynamic principles of environmental building design, in three parts. Oxford: Routledge.

Brickschema.org, 2020. Brick Schema. Document Accessed Online: https://brickschema.org

British Land, 2020. The British Land Company PLC. Document Accessed Online: https://www.britishland.com/

Brown, V.A., Harris, J.A., Russell, J.Y. (Eds.), 2010. Tackling wicked problems: Through the transdisciplinary imagination. London: Earthscan.

Broussard, M., 2019. Artificial Unintelligence. London: MIT Press.

Business Insider Intelligence, 2014. The Internet of everything: 2014. Business Insider. Retrieved from http://www.businessinsider.com/the-internet-of-everything-2014-slide-decksai-2014-2?.

CABE & BCO, 2015. The Impact of Office Design on Business Performance, London: BCO.

Citrix, 2016. Workplace Review, USA: Citrix.

Cao, G., and Pietiläinen, J., 2013. Volume IV – Data collection systems for the management of building energy system in total energy use in buildings – analysis and evaluation methods. International Energy Agency (IEA) – Energy in Buildings and Communities (EBC) Annex 53 Final report.

Checkland, P., 1993. Systems thinking, systems practice. Chichester: Wiley.

Chu, A., Thorne, A., Guite, H., 2004. The impact on mental well-being of the urban and physical environment: An assessment of the evidence. Journal of Public Mental Health Promotion 3 (2), 17–32.

Cisco, 2014. Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, San Jose: Cisco.

Citrix, 2016. Workplace Review, USA: Citrix.

Clements-Croome, D., 2013. Intelligent buildings: design, management and operation. London: ICE Publishing.

Clements-Croome, D., (Ed.), 2014a. Intelligent buildings: an introduction. Oxford: Routledge.

Clements-Croome, D., 2014b. Sustainable Intelligent Buildings for Better Health, Comfort and Well-Being. Denzero EU Project with Debrecen University. Available at: http://www.derekcroome.com/Document%20Files/DENZERO.pdf (accessed 30 July 2016).

Clements-Croome D J., 2013, Chapter 1 in Intelligent Buildings (ICE Publishing)

Clements-Croome, D., Aguilar, A.M., Taub, M., 2015. Putting people first: designing for health and wellbeing in the built environment. British Council for Offices (BCO), London.

Clements-Croome, D., and Taub, M., 2016. The impact of wearables on designing healthy office environments: a wearables diary. Supplemental report for the British Council for Offices (BCO).

Clements-Croome, D., 2017. Creating the Productive Workplace. 3rd Edition, London: Routledge.

Clements-Croome D J., 2019, Sustainable and Liveable Intelligent Buildings (Crowood Press)

Communications/Ebiquity, C., 2015. Global CSR Study, s.l.: Cone Communications/Ebiquity.

Cooper, I., Symes, M. (Eds.), 2011. Sustainable urban development volume 4: Changing professional practice. London: Routledge.

Cuthbertson, A., 2017. China rolls out surveillance system to identify people by their body shape and walk. Independent. Document Accessed Online: https://www.independent.co.uk/news/world/asia/china-surveillance-facial-recognition-body-walk-technology-watrix-privacy-cctv-a8622156.html

Cyviz. 2018. Shaping Innovation Spaces. Oslo: Cyviz.

Daugherty, P., Wilson, H. 2018. Human + Machine. USA: Harvard Business Review Press.

DeKay, M., 2011. Integral sustainable design: Transformative perspectives. London: Earthscan.

Deng, S., Wang, R.Z., Dai, Y.J., 2014. How to evaluate performance of net zero energy building – a literature research. Energy 71, 1–16.

Department of Energy (DoE), 2011. Buildings energy data book. http://buildingsdatabook.eere.energy.gov/ (accessed 28 August 2016).

Domingues, P., Carreira, P., Vieira, R., Kastner, W., 2016. Building automation systems: concepts and technology review. Computer Standards and Interfaces 45, 1–12.

Design Council, 2020. Design Council. Document Accessed Online: https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond

Dodgson, M., Gann, D., 2011. Technological innovation and complex systems in cities. Journal of Urban Technology 18 (3), 101–113.

Dirks, S., Keeling, M., 2009. A vision of smarter cities: How cities can lead the way into a prosperous and sustainable future. New York: IBM Institute for Business Value.

Duvall, T., et al., 2019. A new look at autonomous-vehicle infrastructure. McKinsey & Company: Capital Projects and Infrastructure Practice.

EIU, 2011. LiveanomicsdUrban liveability and economic growth. The Economist Intelligence Unit Report (Commissioned by Philips).

Elliott, C., 2009. Intelligent buildings: Systems engineering for the built environment. Intelligent Buildings International Journal 1 (1), 75–81.

ECA, 2003. Ventilation, good indoor air quality and rational use of energy. In: European Collaborative Action on Urban air, indoor environment and human exposure. Report No. 23.

EUR 20741 EN. Luxembourg: Office for Official Publications of the European Communities.

el-Khoury, R., Marcopoilos, C., Moukheiber, C., 2012. The living breathing thinking responsive buildings of the future. London: Thames & Hudson.

Engin Z. and Treleaven P. (2018) Algorithmic Government: Automating Public Services and Supporting Civil Servants in using Data Science Technologies, The Computer Journal, bxy082, https://doi.org/10.1093/comjnl/bxy082. 11 August 2018.

Epstein, D., 2019. Range: Why generalists thrive in a specialist world. USA: Penguin Random House.

Erhorn, H., and Erhorn-Kluttig, H., 2014. Selected examples of nearly zero-energy buildings – detailed report. Energy performance of buildings – concerted action, European Union. www.epdb-ca.eu.

Erl, T., 2005. Service-oriented architecture – concepts, technology, and design. New York: Prentice Hall.

ERS Research & Consultancy, 2016. Health at Work: Economic Evidence, Milton Keynes.

Ersules, 2016. Engineering Report, Dublin: Ersules.

European Business Summit and Accenture, 2014. Accelerating Europe’s comeback: Digital opportunities for competitiveness and growth. Accenture.

Everest Group & NASSCOM, 2015. Seizing The Robotic Process Automation (RPA) Market Opportunity, Dallas; Noida: Everest Group & NASSCOM.

Farrington, K., 2019. Smart Building Operating System. Barcelona: Smart City World Expo.

Fitbit, 2018. Press Release Details: "Fitbit Reports $571M Q4’17 and $1.616B FY’17 Revenue". [Online] Available at: https://investor.fitbit.com/press/press-releases/press-release-details/2018/Fitbit-Reports-571M-Q417-and-1616B-FY17-Revenue/default.aspx

Fjord, 2016. The Dock. London: Accenture.

Fjord, 2017. Living Services. London: Accenture.

Fjord, 2019. Trends 2019. London: Accenture.

Fuller, K., Cmar, G., Gnerre, B., 2005. Enterprise energy management system. In: Capehart, B.L. (Ed.), Encyclopedia of energy engineering and technology, 3. CRC Press, Boca Raton, FL, pp. 616–624. Chapter 74, Volume Set.

Forkenbrock, D.J., Weisbrod, G.E., 2001. NCHRP REPORT 456: Guidebook for assessing the social and economic effects of transportation projects. Washington, DC: National Academy Press.

Fortune, J., Diana White, D., 2006. Framing of project critical success factors by a systems model. International Journal of Project Management 24 (1), 53–65.

Gartner, 2019. Gartner Says 5.8 Billion Enterprise and Automotive IoT Endpoints Will Be in Use in 2020. Press Release Accessed Online: https://www.gartner.com

Gensler, 2016. Workplace Survey, London: Gensler.

Gharajedaghi, J., 2006. Systems thinking: Managing chaos and complexitydA platform for designing business architecture, 3rd edn. New York: Elsevier.

Ghaffarianhoseini, A., Berardi, U., AlWaer, H., Chang, S., Halawa, E., Ghaffarianhoseini, A., Clements-Croome, D., 2016. What is an intelligent building? Analysis of recent interpretations from an international perspective. Architectural Science Review 59 (5), 338–357.

Goldman, B., 2017. Brain-computer interface advance allows fast, accurate typing by people with paralysis. Stanford Medicine. Document Accessed Online: https://med.stanford.edu/news/all-news/2017/02/brain-computer-interface-allows-fast-accurate-typing-by-people-with-paralysis.html

Gonzalez, R., 2007. Energy management with building automation. ASHRAE Journal 49, 26–32. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.(www.ashrae.org).

Gurumurthy, R., 2019. Pivoting to Digital Maturity. London: Deloitte LLP.

Hagerty, M.R., Cummins, R.A., Ferriss, A.L., Land, K., Michalos, A.C., Peterson, M., et al., 2001. Quality of life indexes for national policy: Review and agenda for research. Social Indicators Research Journal 55 (1), 1–96.

Hanes, D., et al., 2017. IoT Fundamentals. USA: Cisco Press.

Hannon, E., et al., 2016. An integrated perspective on the future of mobility. McKinsey & Company: Sustainability & Resource Productivity.

Hasso Plattner Institute of Design, 2020. Stanford University. Document Accessed Online: https://dschool.stanford.edu/

Hazzenzahl, M., 2008. Proceedings of the 20th Conference on L'interaction Homme-Machine. USA: Association for Computing Machinery.

Hensen, J.L.M., Lamberts, R. (Eds.), 2011. Building performance simulation for design and operation. London: Spon Press.

Henze, G.P., Neumann, C., 2011. Building simulation in building automation systems. In: Hensen, J.L.M., Lamberts, R. (Eds.), Building performance simulation for design and operation. London: Spon Press, pp. 402–440.

Hiremath, R.B., Balachandra, P., Kumar, B., Bansode, S.S., Murali, J., 2013. Indicator-based urban sustainabilitydA review. Energy for Sustainable Development 17 (6), 555–563.

Hollis, T., 2019. Smart Thinking: Design Thinking. London: WSP.

Hong T and Lin H (2013) Occupant behavior: impact on energy use of private offices. ASim 2012 – The 1st Asia conference of International Building Performance Simulation Association (ASim 2012). http://eande.lbl.gov/sites/all/files/lbnl-6128e.pdf.

Hong, T., D'Oca, S., Turner, W., Taylor-Lange, S.C., 2015. An ontology to represent energy-related occupant behavior in buildings. Part I: Introduction to the DNAs framework. Building and Environment 92, 764–777.

Hong, T., Taylor-Lange, S.C., D'Oca, S., Yan, D., Corgnati, S.P., 2016. Advances in research and applications of energy-related occupant behavior in buildings. Energy and Buildings 116, 694–702.

IBM, 2016. Penetration testing a building automation system – is your "smart office" creating backdoors for hackers? IBM X-Force Research Report.

Iconics, 2020. Iconics Automation Software Solution. Document Accessed Online: https://iconics.com/

IDC, 2016. IDC FutureScape: Worldwide Analytics, Cognitive/AI, and Big Data 2017 Predictions, Framingham, MA: IDC.

IDC, 2016. IDC FutureScape: Worldwide Wearables and Augmented Reality/Virtual Reality 2017 Predictions, Framingham, MA: IDC.

Investopedia, 2013. The Causes And Costs Of Absenteeism In The Workplace. [Online] Available at: https://www.forbes.com/sites/investopedia/2013/07/10/the-causes-and-costs-of-absenteeism-in-the-workplace/#24f527d53eb6

International WELL Building Institute, 2014. WELL Building Standard. Available at: http://wellcertified.com (accessed 30 April 2015).

IWBI, 2018. Making the case for better buildings. [Online] Available at: https://www.wellcertified.com/en/articles/making-case-better-buildings

Jayaditya, C., 2020. Fingerprint scanner on Phones: History and Evolution, but do we really need that?. iGadetsWorld. Document Accessed online: https://www.igadgetsworld.com/fingerprint-scanner-history-evolution-but-do-we-really-need-that/#:~:text=The%20world's%20first%20fingerprint%20phone,which%20launched%20back%20in%202004.

Johnson, C.W., 2006. What are emergent properties and how do they affect the engineering of complex systems? Journal of Reliability Engineering and System Safety 91 (12), 1475–1481.

JLL, 2017. Workplace Powered by Human Experience. New York: JLL.

JLL, 2018. The 3-30-300 calculator. [Online] Available at: http://www.us.jll.com/united-states/en-us/services/corporates/consulting/reduce-real-estate-costs [Accessed 9 July 2018].

Karmagianni, M., Weibo. L., et al., 2016. A critical review of new mobility services for urban transport. Transportation Research Procedia 14, 3294-3303.

Kegan, R., Laskow Lahey, L. 2016. An Everyone Culture, USA: Harvard Business Review Press.

Kellert, S.R., Heerwagen, J., Mador, M., 2008. Biophilic design: The theory, science and practice of bringing buildings to life. New Jersey: Wiley.

Kinnaird, C., Geipel, M. and Bew, M. (2017) Blockchain technology – how the inventions behind Bitcoin are enabling a network of trust for the built environment, Arup Foresight report. https://www.driversofchange.com/projects/blockchain-technology-how-the-inventions-behind-bitcoin-are-enabling-a-network-of-trust-for-the-built-environment/

Köhn, R., 2018. "Konzerne verbünden sich gegen Hacker" - Corporations Ally Themselves Against Hackers (sic). [Online] Available at: http://www.faz.net/aktuell/wirtschaft/diginomics/grosse-internationale-allianz-gegen-cyber-attacken-15451953-p2.html?printPagedArticle=true#pageIndex_1

Kolarevic, B., Parlac, V. (Eds.), 2017. Building dynamics: exploring the architecture of change. London and New York: Rountledge.

KPMG International (2013). Future state 2030: The global megatrends shaping governmentsdGlobal Megatrend #5: Public Debt. KPMG International.

Komninos, N., 2011. Intelligent cities: Variable geometries of spatial intelligence. Intelligent Buildings International 3 (3), 172–188.

Krope, J., Goricanec, D., 2009. Energy efficiency and thermal envelope. In: Mumovic, D., Santamouris, M. (Eds.), A handbook of sustainable building design and engineering – an integrated approach to energy, health and operational performance. London: EarthScan, pp. 23–33.

Lawson, B., 2008. The Language of Space. 1 ed. Oxford: Architectural Press.

Lawrence, R.J., 2010. Chapter 2. Beyond disciplinary containment to imaginative transdisciplinarity. In: Brown, V.A., et al. (Eds.), Tackling wicked problems: Through the transdisciplinary imagination. London: Earthscan.

Lewrick, M., Et al., 2018. The Design Thinking Playbook. Munich: Wiley.

Levermore, G.J., 2000. Building energy management systems: applications to low-energy HVAC and natural ventilation control, 2nd edn. London: Talyor & Francis.

Li, J., Greenwood, D. and Kassem, M. (2018) Blockchain in the built environment: analysing current applications and developing an emergent framework, Proc. Creative Construction Conference 2018, CCC 2018, 30 June - 3 July 2018, Ljubljana, Slovenia.

Loftness, V., Lam, K.P., Hartkopf, V., 2005. Education and environmental performance-based design: a Carnegie Mellon perspective. Building Research & Information 33 (2), 196–203.

Lyonnais, S., 2017. Where Did the Term “User Experience” Come From?. Adobe Blog. Document Accessed Online: https://blog.adobe.com/en/publish/2017/08/28/where-did-the-term-user-experience-come-from.html#gs.h42618

Matos, J., 2018. Measuring WELL: ASID post-occupancy analysis highlights the value of designing WELL. [Online] Available at: https://www.wellcertified.com/en/articles/measuring-well-asid-post-occupancy-analysis-highlights-value-designing-well

Maslow, A., 1943. A theory of human motivation. Psychological Review 50, 370–396.

McKinsey Global Institute (2017) Reinventing construction: a route to high productivity.https://www.mckinsey.com/~/media/McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/Reinventing%20constructi on%20through%20a%20productivity%20revolution/MGI-Reinventing-Construction-Executive-summary.ashx

Mason, N., 2019. What's the 3-30-300 Rule and How Can Facility Manager Use It?. Office Space Software. Document Accessed online: https://www.officespacesoftware.com/blog/whats-the-3-30-300-rule-and-how-can-facility-managers-use-it

Marson, M., 2020. Client Case Study Interview.

Marson, M., Kinch, J., 2020. The challenges of retrofitting smart systems into existing buildings. London: RICS.

McHale, J., 2018. Growth in the Smart Buildings Market at Smart Buildings Conference, Amsterdam: Memoori.

Meister, J., 2015. The Future Of Work: Airbnb CHRO Becomes Chief Employee Experience Officer. [Online] Available at: https://www.forbes.com/sites/jeannemeister/2015/07/21/the-future-of-work-airbnb-chro-becomes-chief-employee-experinece-officer/#7d651c642327

Medicine, A. A. o. S., 2009. Better Sleep Is Associated With Improved Academic Success. [Online] Available at: https://www.sciencedaily.com/releases/2009/06/090610091232.htm

Memoori, 2019. Market Update 2019. Stockholm: Memoori

Moore, F., 1993. Environmental control systems – heating cooling lighting. Architecture and urban planning series. New York: McGraw-Hill International Edition.

Microsoft, 2020. Power BI. Document Accessed Online: https://powerbi.microsoft.com/en-us/

Mikkelson, D., Soller, H., Strandell-Jansson, M., 2020. Privacy, Security, And Public Health In A Pandemic Year. Mckinsey & Company. Document Accessed Online: https://www.mckinsey.com/business-functions/risk/our-insights/privacy-security-and-public-health-in-a-pandemic-year

Miller, D., Baskin, J., 2019. What's Your Curb Index? New York: Coord.

Mintel, 2020. UK Courier And Express Delivery Incl Impact Of COVID-19 Market Report. London: Mintel.

Morgan, J., 2017. The Employee Experience Advantage: How to win the war for talent by giving employees the workspaces they want, the tools they need, and a culture they can celebrate. London: Wiley.

Mumovic, D., Santamouris, M. (Eds.), 2009. A handbook of sustainable building design and engineering – an integrated approach to energy, health and operational performance. Oxford: EarthScan.

Nakamoto (2018) What's the difference between blockchain and DLT? https://medium.com/nakamo-to/whats-the-difference-between-blockchain-and-dlt-e4b9312c75dd

Nilon, C.H., Berkowitz, A.R., Hollweg, K.S., 2003. Introduction: Ecosystem understanding is a key to understanding cities. In: Berkowitz, A.R., et al. (Eds.), Understanding urban ecosystems: A new frontier for science and education. New York: Springer, pp. 1–14.

Nordrum, A., 2016. Popular Internet of Things Forecast of 50 Billion Devices by 2020 Is Outdated. [Online] Available at: https://spectrum.ieee.org/tech-talk/telecom/internet/popular-internet-of-things-forecast-of-50-billion-devices-by-2020-is-outdated

O'Brien, W., et al., 2020. Introducing IEA EBC annex 79: Key challenges and opportunities in the field of occupant-centric building design and operation. Building and Environment Journal 187

Okraglik, H., 2019. Smart Thinking: Appification of Everything. London: WSP.ANFA. 2018, September. Shared Behavioral Outcomes. Academy of Neuroscience

Piette, M.A., Granderson, J., Wetter, M., Kiliccote, S., 2012. Intelligent building energy information and control systems for low-energy operations and optimal demand response. IEEE Design and Test of Computers 29 (4), 8–16.

Phillips, Amsterdam. The Edge, 2017: Phillips.

Portman, J., 2014. Building service design management. West Sussex: Wiley.

Project Haystack, 2020. Project Haystack. Document Accessed Online: https://project-haystack.org

Ratti, C., Claudel, M., 2016. The city of tomorrow: Sensors, networks, hackers and the future of urban life. New Haven: Yale University Press.

Reed, R., Bilo, A., Wilkinson, S., Schulte, K.W., 2009. International comparison of sustainable rating tools. Journal of Sustainable Real Estate 1 (1), 1–22.

RIBA, 2013. Royal Institute of British Architects (RIBA) – guide to using the RIBA plan of work 2013. London: RIBA Publishing.

RICS (2018) Big data, smart cities, intelligent buildings – surveying in a digital world.https://www.rics.org/globalassets/rics-website/media/knowledge/research/insights/big-data-smart-cities-intelligent-buildings-surveying-in-a-digital-world-rics.pdf

Rock, D., Grant, H., 2016. Why Diverse Teams Are Smarter. USA: Harvard Business Review.

Rogers, R., 1997. Cities for a small planet. London: Faber and Faber.

Roman, A., 2008. Curitiba, Brazil. In: Cleveland, C.J. (Ed.), Encyclopedia of earthdEnvironmental information coalition. National Council for Science and the Environment,bWashington, DC (Revised 2011).

Rossow, A., 2018. The Birth OF GDPR: What It Is And What You Need To Know. Forbes. Document Accessed Online: https://www.forbes.com/sites/andrewrossow/2018/05/25/the-birth-of-gdpr-what-is-it-and-what-you-need-to-know/#6429e92055e5

Saaty, T.L., 2000. Fundamentals of the analytic hierarchy process. Pittsburgh, PA: RWS Publications.

Sarkisian, M., 2016. Designing tall buildings – structure as architecture, 2nd edn. London: Routledge.

Savage, M., 2018. Thousands Of Swedes Are Inserting Microchips Under Their Skin. NPR. Document Accessed Online: https://www.npr.org/2018/10/22/658808705/thousands-of-swedes-are-inserting-microchips-under-their-skin?t=1601070482895

Schippers, B., 2016. App Fatigue. Article Accessed Online: https://techcrunch.com

Schoder, D. & Hassan, Q. F., 2018. Internet of Things A to Z: Technologies and Applications. s.l.:Wiley-IEEE Press.

Schumacher, E.F., 1973. Small is beautiful: A study of economics as if people mattered. London: Blond and Briggs.

Schwab, K., 2018. Shaping the Future of the Fourth Industrial Revolution. Switzerland: World Economic Forum.

Shepard, M., 2009. Curatorial statement: Toward the sentient city exhibition. The Architectural League of New York. http://www.sentientcity.net/exhibit/?p¼3.

Sheppard, B., Kouyoumjian, G., Sarrazin, H., Dore, F., 2018. McKinsey Quarterly - The Business Value of Design. Mckinsey & Company. Document Accessed Online: https://www.mckinsey.com/business-functions/mckinsey-design/our-insights/the-business-value-of-design

Short, C.A., Lomas, K.J., Giridharan, R., Fair, A.J., 2012. Building resilience to overheating into 1960's UK hospital buildings within the constraint of the national carbon reduction target: adaptive strategies. Building and Environment 55, 73–95.

Sinclair, D. (Ed.), 2012. BIM overlay to the RIBA outline plan of work. London: RIBA Publishing.

SMART 2020, (2011). Information marketplaces: The new economics of cities, Report by The Climate Group, Arup, Accenture and University of Nottingham.

Smith, A., 2016. Gig Work, Online Selling and Home Sharing. [Online]

Available at: http://www.pewinternet.org/2016/11/17/gig-work-online-selling-and-home-sharing/

Sodexo, 2016. Workplace Trends, Issy-les-Moulineaux: Sodexo.

Srijith, K., et al., 2010. Towards Secure Cloud Bursting, Brokerage and Aggregation. IEEE: 2010 Eighth IEEE European Conference on Web Services

Stanley, P., 2018. Designing for accessibility is not that hard. UX Collective. Document Access online: https://uxdesign.cc/designing-for-accessibility-is-not-that-hard-c04cc4779d94

Statt, N., 2016. Boeing is using Google Glass to build airplanes. [Online] Available at: https://www.theverge.com/2016/7/14/12189574/boeing-google-glass-ar-building-airplane-parts

Stoddart, 2016. The Workplace Advantage. London: Raconteur.

Tang, G., 2010. MasdardThe sustainable desert city: A theoretical mirage or a realistic possibility? In: Lehmann, S., Al-Waer, H., Al-Qawasami, J. (Eds.), Proceedings ofnArchitecture and Urban Development (SAUD 2010) Conference, Vol III, Sustainable. CSAAR, Amman, pp. 175–189.

Towler, J., and Lawson, H., 2014. Smart evolution: technical and social convergence. The Building Services Research and Information Association (BSRIA) Business Network Meeting, Bracknell, 20 March 2014.

Tech @ Facebook, 2020. Imagining a new interface: Hands-free communication without saying a word. Facebook. Document Accessed Online: https://tech.fb.com/imagining-a-new-interface-hands-free-communication-without-saying-a-word/

The light phone inc., 2020. The Light Phone. Document Accessed Online: https://www.thelightphone.com/

Tymkow, P., Tassou, S., Kolokotroni, M., Jouhara, H., 2013. Building services design for energy efficient buildings. Oxford: Routledge.

UN, 2014. World urbanization prospects: the 2014 revision, highlights (ST/ESA/SER.A/352). United Nations: Department of Economic and Social Affairs, Population Division. https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf (accessed 06 August 2016).

UN Habitat, 2011. The state of the world's cities. UN Habitat.

Unify, 2014. New Ways of Working, Munich: Unify.

Vogel, D., Dickson, G., et al., 1986. Persuasion and the Role of Visual Presentation Support: The UM/3M Study. Minnesota: MISRC, University of Minnesota.

Welter, V.M., 2002. Biopolis: Patrick Geddes and the city of life. Cambridge, MA: MIT Press.

Williams, H., 2017. Challenger bank Monzo clinches £71m and hits £280m valuation. [Online] Available at: https://startups.co.uk/monzo-clinches-71m-and-hits-280m-valuation/

Wilson, E.O., 1986. Biophilia: The human bond with other species. Cambridge, MA: Harvard University Press.

Worall, M., 2011. Homeostasis in nature: nest building termites and intelligent buildings. Intelligent Buildings International 3, 87–95.

World Bank, 2011. Migration and remittance factbook. The World Bank.

World Green Building Council, 2014. Health, wellbeing and productivity in offices: the next chapter for green building, World Green Building Council. http://www.ukgbc.org/resources/publication/health-wellbeing-and-productivity-offices-next-chapter-green-building (accessed 28 August 2016).

WSP, 2020. Confidential city in Kingdom of Saudi Arabia. London: WSP.

Zeiler, W., Vissers, D.R., Maaijen, H.N., Boxem, G., 2014. Occupants' behavioural impact on energy consumption: 'human-in-the-loop' comfort process control. Architectural Engineering and Design Management 10 (1–1), 108–130.

Zhao, J., Lam, K.P., Ydstie, B.E., Loftness, V., 2016. Occupant-oriented mixed-mode EnergyPlus predictive control simulation. Energy and Buildings 117, 362–371.

Zhou, B., Li, W., Chan, K.W., Cao, Y., Kuang, Y., Liu, X., Wang, X., 2016. Smart home energy management systems: concept, configurations, and scheduling strategies. Renewable and Sustainable Energy Reviews 61, 30–40.

12. Appendix A

List of podcast transcripts included (https://soundcloud.com/smart-thinking):

Title	Authors	About the Interviewee	Published
1 - What is a Smart Building?	Marson, M.	-	14/03/2019
2 - The Value of Smart Building	Marson, M., et al.	-	21/03/2019
3 - Why Smart Buildings are Difficult	Marson, M.	-	28/03/2019
4 - Smart and Holistic Engineering	Marson, M., Moazami, K., Richards, J.	Managing Director of Property & Buildings, WSP UK	04/04/2019
5 - The Digital Transformation of Engineering	Marson, M., Offer, N.	Head of Building Services, WSP UK	11/04/2019
6 - Digital Services & Service Design	Marson, M., Hollis, T.	Proposition Designer at Market Gravity	18/04/2019
7 - HVAC Analytics	Marson, M., Patel, M.	Director of Solutions, ICONICS	25/04/2019
8 - Smart Lighting	Marson, M., Wrattan, J.	Vice President, WSP USA	02/05/2019
9 - Smart for Operations	Marson, M., Biswas, A.	Director of Transformation, MITIE	09/05/2019
10 - Human Centred Design	Marson, M., Sossa, M.	Delta Airlines	16/05/2019
11 - Smart Healthcare	Marson, M., Rome, N., Cassidy, K.	Head of Healthcare, WSP Global	23/05/2019
12 - Measuring Productivity	Marson, M., Jarvis, S.	Director, Cordless Consultants	30/05/2019
13 - Location Services	Marson, M., Hogan, E.	Specialist, Cordless Consultants	06/06/2019
14 - Digital Wellness	Marson, M., Knibb, H.	Development Director, Oxford Properties	13/06/2019
15 - Ethics	Marson, M., Clarke, C.	Consultant, Accenture	20/06/2019
16 - Drivers for Strategic Value	Marson, M., Smith, T.	Global Director of Property & Buildings, WSP	27/06/2019
17 - New Business Models for Developers	Marson, M., Wrattan, J.	Vice President, WSP USA	04/07/2019
18 - Security	Marson, M., Richards, P.	Director, WSP Canada	11/07/2019

19 - Access Control	Marson, M., Brittle, M.	Director, WSP UK	18/07/2019
20 - Platforms	Marson, M., Russel, P.	Smart Buildings Leader, IBM	25/07/2019
21 - APIs/AI	Marson, M., Chatupt, C.	CEO, Placemake.io	01/08/2019
22 - Appification	Marson, M., Okraglik, H.	CEO, WSP Digital	08/08/2019
23 - Blockchain	Marson, M., Jones, J., McDermott, P.	Director, BTC	15/08/2019
24 - Smart Cities	Marson, M., Alexander, J.	Head of Smart Cities, Siemens	22/08/2019
25 - Converged Network	Marson, M., Singh, R.	Technical Director, WSP Australia	29/08/2019
26 - Smart Stadia	Hammer, N., Marson, M., Wrattan, J.	Vice President, WSP USA	05/09/2019
27 - Middle East Striving for Smart Success	Marson, M., Todd, G.	Director, WSP Middle East	12/09/2019
28 - Global smart Workplace Strategy Project	Hammer, N., Marson, M., Els, H.	Senior Vice President, WSP USA	19/09/2019
29 - Smart Design	Marson, M., Salam, D.	Founder, Studio DS	26/09/2019
30 - Round Up	Marson, M., et al.	-	03/10/2019

1. **Brown, K., et al., 2016.** ***Environmental Sustainability Principles for the Real Estate Industry,*** **Davos: World Economic Forum.**

This publication has been redacted for copyright reasons.

2 Yang, T., Clements-Croome, D. & Marson, M., 2017. *Building Energy Management Systems*. In: M. A. Abraham, ed. Encyclopaedia of Sustainable Technologies. London: Elsevier, pp. 291-309.

This publication has been redacted for copyright reasons.

3. Clements-Croome, D., Marson, M. & Yang, T., 2017. *Planning and Design Scenarios for Liveable Cities*. In: M. A. Abraham, ed. Encyclopaedia of Sustainable Technologies. London: Elsevier, pp. 81-97.

This publication has been redacted for copyright reasons.

Publication 415

Research Roadmap

Intelligent and Responsive Buildings

International Council
for Research and Innovation
in Building and Construction

This publication is written in association with CIBSE Intelligent Buildings Group.

Title	Research Roadmap for Intelligent and Responsive Buildings
Serial title	415
Year	2018
Editor	Derek Clements-Croome
Language	English
Pages	67 p.
Key words	Intelligent Buildings, Technology, Health, Wellbeing, Liveability, Biophilia, Infrastructure, Holistic design, Sustainability
ISBN	978-90-803022-9-7
Publisher	CIB General Secretariat Van der Burghweg 1 2628 CS, Delft The Netherlands E-mail secretariat@cibworld.nl www.cibworld.nl

Credit Cover photo: The Believe in Better Building for Sky by Arup Associates; zero fossil fuel to site, zero carbon in construction, adopting reduce/re-use/recycle with advanced user-centred design and operation.

CIB W098 Research Roadmap for Intelligent and Responsive Buildings

Table of Contents

1. Conceptual Framework

Derek Clements-Croome

> *An intelligent building is one that is responsive to the requirements of occupants, organisations and society. It is sustainable in terms of energy and water consumptions besides being lowly polluting in terms of emissions and waste: healthy in terms of well-being for the people living and working within it; and functional according to the user needs.*
>
> Clements-Croome, 2009

Intelligent buildings need to be sustainable. This means sustaining their performance with respect to energy, water, waste and pollution for future generations. Beyond this, intelligent buildings should be healthy places to live and work in; be equipped with appropriate reliable technology; meet regulations; respond to the needs of the occupants; be flexible, adaptable and durable; give value for money. Architecture provides landmarks in our civilization so their visual appeal remains important too.

Buildings will contain a variety of systems designed by people, and yet the relationship between buildings and people can only work satisfactorily if there is **integration** between the supply (design consultants, contractors and manufacturers) and demand (developers, building owners and occupants) side stakeholders as well as between the occupants, the systems and the building. **Systems thinking** is essential in planning, design and management, together with the ability to create and innovate whilst remaining practical. All this requires **holistic thinking**. Table 1 summarises the main characteristics of holistic thing in contrast to an atomistic approach.

Table 1: Atomistic Technical and Holistic Socio-technical Approaches to the Built Environment [based on Munro 2011]

	Atomistic	Holistic
Nature	• Narrow: concentrates on individual elements	• Broad: elements seen as inter-related; interoperability important
Perspective	• Individual systems in isolation • Single discipline outlook	• Whole system • Interdisciplinary and transdisciplinary outlook
Cause and Effect	• Looking only at immediate effects • Short chains of causality	• Separated in space and time • Long chains of causality, ripple effects, unintended consequences, feedback effects

Style of Recommendations	• Technocratic • Regulation and compliance	• Socio-technical • Beyond regulations
Results (observed and sought)	• Narrow range of responses to user's needs • Defensive management of risk • Command and control management; frameworks and procedures; squeezing out professional discretion and creativity • Compliance culture • Focus on standardised processes, frameworks and procedures	• Flexible responses to meeting user's needs • Acceptance of irreducible risk • Supportive management encouraging creativity, discovery and enterprise • Comprehensive feedback • Focus on building users their needs with pathways giving high value outcomes such as good well-being and high productivity

A lot of terms are used. Should we say intelligent or smart buildings? Then there is the sentient building which describes how well the building responds to the occupants changing needs. A sentient building should be measured continually with a sensor network which can predict and also activate change according to circumstances and user preferences. With respect to cities, the automation and digital aspects especially in information and communications technology are the smart elements which are important but a building needs also to respond to social and environmental factors and this features the language of low tech passive environmental design. An intelligent building increases the environmental socio-economic value (see Fig. 1).

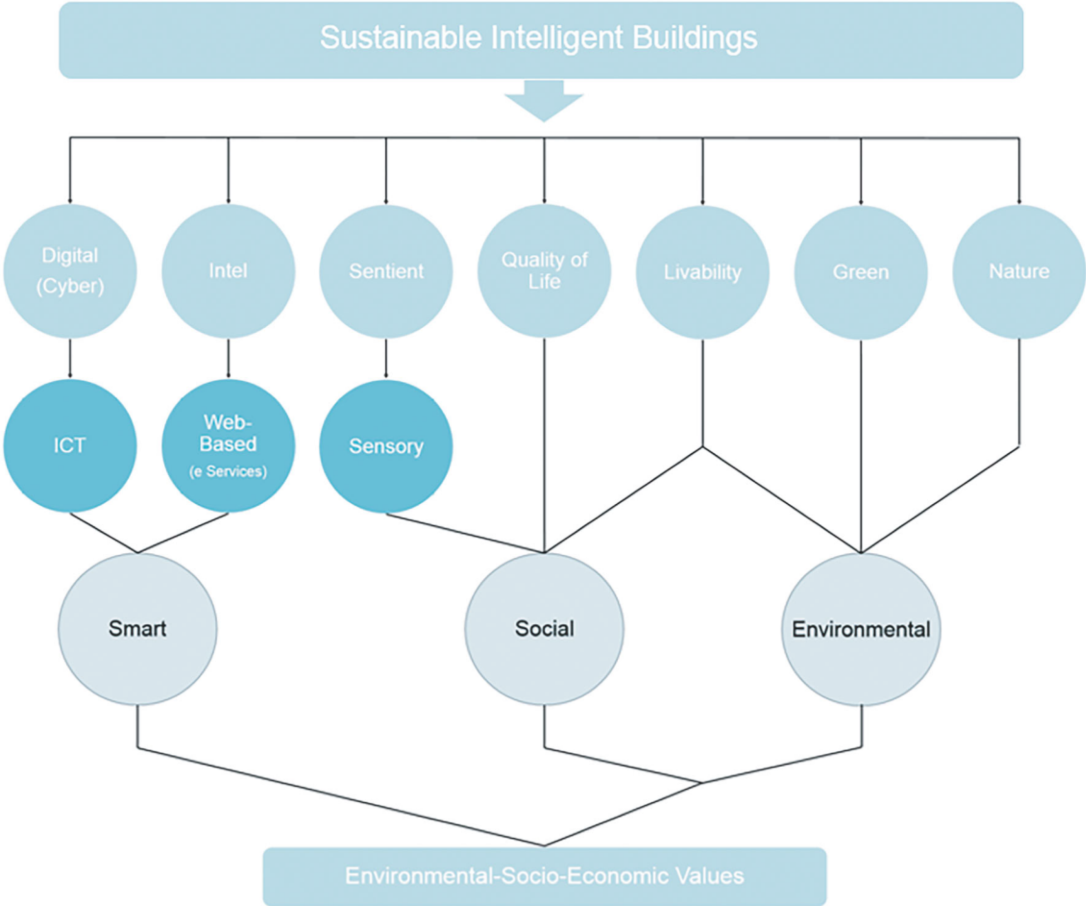


Figure 1. Key constituents of Intelligent Buildings [Clements-Croome 2013, p. 289].

The ultimate objective should be simplicity rather than complexity and this is best achieved by naturally responsive architecture. This not only requires technical ability but also the powers of interpretation, imagination and even intuition. Building Regulations can stifle creations but are necessary to set a minimum level of expectation and obey health and safety requirements. However we should aim to design well above these conditions. After all, buildings form our architectural landscape and they, and the environment they generate, should uplift the soul and the spirit of those people within them as well as those who pass by them. Clements-Croome [2018] proposes a Flourish model as a model for user centred design.

The creation of shared visions, effective teams, clear and robust design and management processes ensures that the intelligent building will effectively demonstrate in use the purpose for which it was conceived. Times are changing as technology and society evolve so there needs to be a long term outlook by the team. Key innovation issues for intelligent buildings include sustainability (energy, water, waste and pollution), the use of 3D and 4D printing technologies, the use of information and communication technology, robotics, embedded sensor technology, smart-materials technology including nanotechnology, health in the workplace and social change.

Facades using smart materials for example will provide sophisticated forms of feedback and high levels of control besides regulating heat air and light transmissions. By coating and embedding materials with nano-particles we will be able to specify material properties much more easily [Pacheco-Torgal et al 2013; Pacheco-Torgal and Labrincha 2013]. Structures with zinc oxide nano coatings for example can accelerate heat dissipation. Self-healing materials will revolutionize facades in the future. Pelletier and Bose [2010] describe how a concrete matrix embedded with capsules of sodium silicate healing agent can repair cracks by the sodium silicate from the ruptured capsules interacting with the calcium hydroxide in the concrete to form a gel which seals the cracks.

In contrast one must not forget that basic materials like hemp, straw, rammed earth, waste composites and wool and seaweed bricks all offer sustainable solution possibilities. Cloth made from lotus stems was reported in the Financial Times 9 March 5th/6th 2011. Novacem concrete is a low embodied energy material developed at Imperial College in London. In the future graphene new material can be expected to make its impact on façade designs.

However innovation should be an enabler rather than an end in itself. Passive environmental design is equally important so that the energy demands are minimized by using natural means such as mass, orientation and building form to capture sunlight, fresh air and rain water. But we cannot ignore the rapid developments in digital technology. In the words of the Hong Kong architect James Law:

> *In the 21st Century, buildings will be different from 20th Century. They are no longer about concrete, steel and glass, but also the new intangible materials of technology, multimedia, intelligence and interactivity. Only recognizing this will bring a new form of architecture to light, namely a Cybertecture.*

References

Clements-Croome, D. J. (2013). Intelligent Buildings: Design, Management and Operation. 2nd ed. London: ICE Publishing.

Clements-Croome, D. (ed.). (2018). Creating the Productive Workplace: Places to Work Creatively. 3rd edn. London & New York: Taylor & Francis.

2. Future of Intelligent Buildings: A Critical Debate on Key Performance Indicators

Amirhosein Ghaffarianhoseini, Derek Clements-Croome Ali Ghaffarianhoseini, Husam AlWaer, John Tookey

2.1 Conceptual framework

In recent years, design and implementation of greener and smarter buildings has indicated growing trends [Ghaffarianhoseini et al. 2016; Xie et al. 2017]. This is evidently observed in several recent practices globally, on top of the significantly increased number of research publications in the areas of sustainable and intelligent buildings.

Notwithstanding the widely well-known concepts of green, sustainable and intelligent buildings, their embedded essence and ultimate impacts are evolving and adjusting to cultural and social changes. Current body of literature confirms that, advancement of intelligent buildings (IBs) is frequently claimed to be a promising solution towards achieving enhanced building performance. While being efficiently equipped with state of the art technologies, ICT, and automated systems, IBs are highly responsive to the needs of their occupants besides being optimally operational. IBs have also proven to be capable of deploying sustainable design initiatives to enhance the overall performance of buildings and maintain an acceptable level of occupant comfort [Ghaffarianhoseini et al. 2016; Clements-Croome 2013]. Nevertheless, IBs have been interpreted in many diversified ways. This complex has led to the true potential of IBs not being fully revealed [Ghaffarianhoseini et al. 2016; Clements-Croome 2013]. Research endeavours to shed light on the state of the art of IBs, the most crucial agendas related to their current development, along with their future directions, as illustrated in Figure 2. As initially suggested by AlWaer and Clements-Croome [2010] who developed a detailed set of

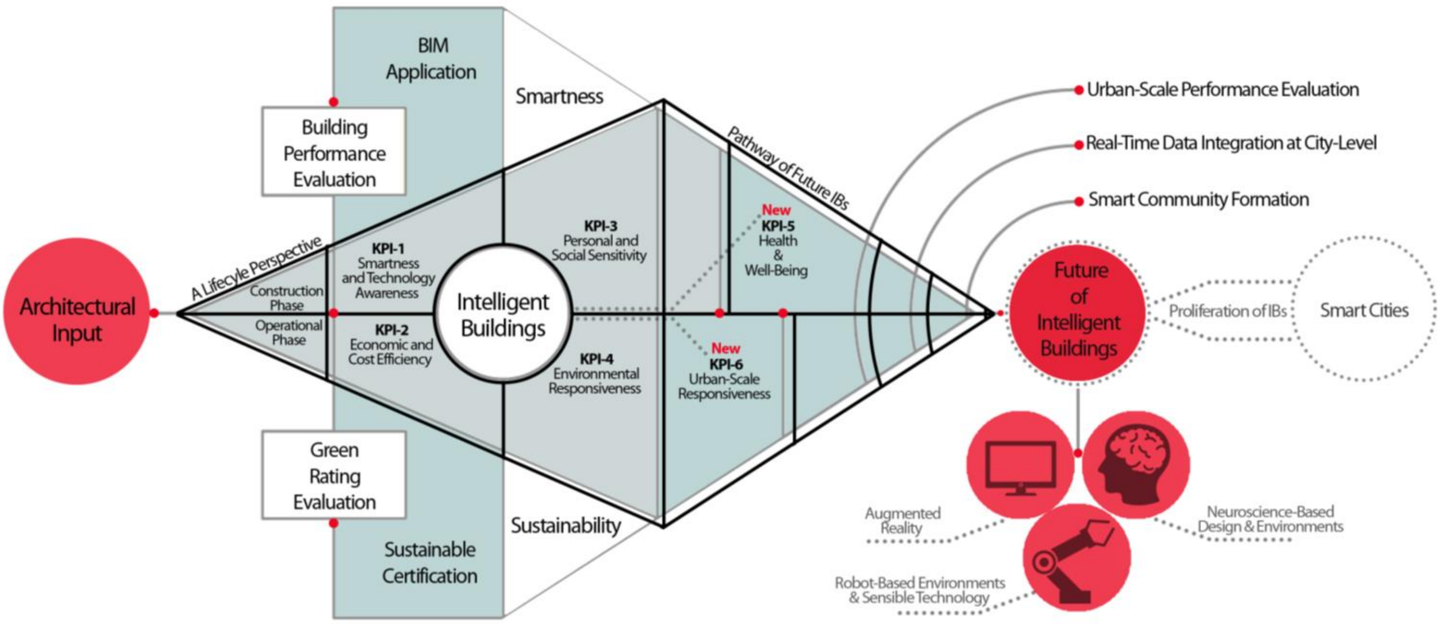


Figure 2. State-of-the-art Overview of Pathways towards Formation of Future IBs

key performance indicators (KPIs) for IBs and later expanded by Ghaffarianhoseini et al [2016], and Clements-Croome [2018] to include health and wellbeing and urban scale responses.

2.2 State of the Art

Several recent studies endeavoured to define IBs, identify their core attributes and set platforms for analyzing their effectiveness [Clements-Croome 2018]. Concerning one of the most recent representation of IBs, six main KPIs are defined [Ghaffarianhoseini 2016]:

KPI-1) Smartness and Technology Awareness,
KPI-2) Economicst and Cost Efficiency to give high value,
KPI-3) Personal and Social Sensitivity and,
KPI-4) Environmental Responsiveness.
KPI-5) Health &Well-Being and,
KPI-6) Urban-Scale Responsiveness.

IBs should go beyond automation and performance dimensions, in order to address a multi-dimensional set of criteria. This proposal suggests integration with emerging technologies in order for IBs to become more responsive to users' needs, value driven and productive [Clements-Croome 2018]. These are on top of becoming adequately adaptable to social and technological changes. This pathway to achieving smarter environments not only requires deploying cutting edge technologies (i.e. use of augmented reality (AR), intelligent energy management systems and/or electroencephalography (EEG) integration) [Vecchiato et al. 2015; Zhou et al. 2016], new design initiatives (i.e. biomimicry design) [Zari 2016] and advanced digital systems (i.e. real-time data sensor integrations) but also needs smarter users and professionals. Therefore, it is important to clarify the interrelated and collective roles of users and communities plus enlightening the interconnected responsibilities of professionals and academicians, in order to achieve the outlined targets.

2.3 Future scenario

Are we aware of the current challenges and drawbacks towards development of solid future IBs?
Do we know the exact degree of necessity on the progression of future IBs?
Are construction professionals and building scientists aware of their role in development and maximizing the ultimate impacts of future IBs?

With the focus of recent studies on the sick building syndrome and the need for healthy buildings [Xie et al. 2017; Clements-Croome 2018; Heidari et al. 2017], the significance of developing healthier IBs, to achieve a higher level of comfort, well-being and productivity [Clements-Croome 2017], is emphasized on. Indeed, the healthy design concept is foreseen to become a focal element for future development of buildings. This is primarily based on its potentials for health improvement, users satisfaction and the associated economic gains. Besides, as smart cities are becoming a main focus of governmental sectors [Deakin & Al Waer 2012; Albino et al. 2015], there is a fundamental need to fill the existing gap between IBs and the smart urban future. As a result, IBs should also be evaluated from an urban-scale perspective to ensure their contribution at city-level. In fact, proliferation of IBs plays a key role towards achieving a truly smart city. This is clearly alongside the urgency for smart infrastructures [Albino et al. 2015]

2.4 Development strategy

Future IBs demand coherent incorporation of cutting-edge digital technologies and building design in order for their true benefits to be extended. In particular, with the emergence of AR in the architectural context, from conceptual design and development to the operational phase, integration of AR can be an inherent attribute of future IBs. IBs, as the embodiment of highly automated living environments, can become more operationally resourceful and user friendly once deploying AR. Visualizing real-time building and city data in an indoor living environment can be seen as a basis for new methods of maximizing IBs' potentials based on the virtual interactions of users, buildings and urban areas. On the other side, with the emergence of robotics in architectural design and construction, IBs can not only benefit from a more efficient development process (i.e. use of robotics in off-site construction, prefabrication phases and parametric design), but can also be equipped with robot-assisting living environments during the operational phase to enhance safety, security and comfort. Furthermore, from a neuroscience perspective, future IBs not only need to be aware of their impacts on comfort, well-being and satisfaction of occupants, but also should be cognizant of occupants' mood, sensation and feeling via monitoring the brain responses of their users using EEG. Meanwhile, the importance of integrating IBs with Building Information Modelling (BIM) for life-cycle design, operation and maintenance of buildings is signified [Ghaffarianhosein et al. 2017]. Thus, presenting an interdisciplinary development strategy, IBs of future will push the current boundaries to autonomously receive and analyze the real-time impacts of their embedded living environments on the mental responses of theirs users and their health status, plus their influence in the urban-scale performance of the city. This can result in development of ultra-healthy IBs for more tangible contribution to the well-being of occupants and the performance of a city.

2.5 Research Contribution

IBs should be seen as a research-based evolutionary entity that requires continuous upgrade and incorporation of new initiatives both from professional practice and academic perspectives. Literature presents that IBs were repeatedly suggested to become the main umbrella encompassing several targets for achieving green, energy efficient, zero energy, zero carbon, smart and digital built environments. This allows synchronizing all attributes in one set of database for a collective contribution to the next stages of IB development. Above this contemplation, to the best knowledge of the authors, no or very insignificant number of studies have attempted to discuss the gap between IBs and smart cities. In fact, for achieving intelligent urban areas as part of a smart city [Albino et al. 2015], despite the existence of several drawbacks towards a massive proliferation of IBs in an urban area, with the aim of large-scale contribution to the goals of smart city, more in-depth analysis on IBs is required to be carried out.

2.6 Research Agenda

There is no doubt that a key agenda of the 21th century is to amplify the awareness and propose practical solutions regarding the impacts of rapid urbanization [Lehmann 2017]. While to some extent, the rapid urban growth in many mega cities and their surrounding context is inevitable, this study suggests that utilization of IBs, once fully assessed from both building and urban scale perspectives, can provide significant positive impacts. In particular, the study demonstrates that IBs embrace a huge capacity for reducing the negative environmental impacts of urbanization, balancing the digital lifestyle of users with living and working environments plus providing healthier indoor living environments and urban communities. The conceptual framework also implies that IBs can be the central point for formation of smart communities and their large-scale performance besides their real-time data integration at city level can uplift the performance of a city. Likewise, it is elaborated that integration of BIM, AR technology, robotic-based environments and neuroscience-based building design are four core lines of future IB developments. These new dimensions of IBs create a wide platform for more in-depth interdisciplinary research to create the IBs of future from architecture, building construction, digital technology and ICT to urban design, city planning and computational parametric modelling.

References

Albino, V., Berardi, U., &Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. Journal of Urban Technology, 22(1), 3-21.

Al Waer, H., & Clements-Croome, D. J. (2010). Key performance indicators (KPIs) and priority setting in using the multi-attribute approach for assessing sustainable intelligent buildings. Building and Environment, 45(4), 799-807.

Clements-Croome, D. J. (2013). Intelligent Buildings: Design, Management and Operation. 2nd ed. London: ICE Publishing.

Clements-Croome, D. (ed.). (2018). Creating the Productive Workplace: Places to Work Creatively. 3rd edn. London & New York: Taylor & Francis.

Deakin, M., & Al Waer, H. (Eds.). (2012). From intelligent to smart cities. Routledge.

Ghaffarianhoseini, A., Berardi, U., Al Waer, H., Chang, S., Halawa, E., Ghaffarianhoseini, A., & Clements-Croome, D. (2016). What is an intelligent building? Analysis of recent interpretations from an international perspective. Architectural Science Review, 59(5), 338-357.

Ghaffarianhoseini, A., Tookey, J., Ghaffarianhoseini, A., Naismith, N., Azhar, S., Efimova, O., & Raahemifar, K. (2017). Building Information Modelling (BIM) uptake: Clear benefits, understanding its implementation, risks and challenges. Renewable and Sustainable Energy Reviews, 75, 1046-1053.

Heidari, L., Younger, M., Chandler, G., Gooch, J., & Schramm, P. (2017). Integrating health into buildings of the future. Journal of Solar Energy Engineering, 139(1), 010802.

Lehmann, S. (2017). Conceptualising the Urban Nexus framework for a circular economy: linking energy, water, food and waste (EWFW) in Southeast-Asian cities. In Urban Energy Transition: from Fossil Fuels to Renewable Power. Elsevier.

Vecchiato, G., Tieri, G., Jelic, A., De Matteis, F., Maglione, A. G., & Babiloni, F. (2015). Electroencephalographic correlates of sensorimotor integration and embodiment during the appreciation of virtual architectural environments. Frontiers in psychology, 6.

Xie, H., Clements-Croome, D., & Wang, Q. (2017). Move beyond green building: A focus on healthy, comfortable, sustainable and aesthetical architecture. Intelligent Buildings International, 9(2), 88-96.

Zari, M. P. (2016). Mimicking ecosystems for bio-inspired intelligent urban built environments. Intelligent Buildings International, 8(2), 57-77.

Zhou, B., Li, W., Chan, K. W., Cao, Y., Kuang, Y., Liu, X., & Wang, X. (2016). Smart home energy management systems: Concept, configurations, and scheduling strategies. Renewable and Sustainable Energy Reviews, 61, 30-40.

3. Health and Wellbeing oriented Indoor Built Environments for Future Intelligent Buildings

Quan Jin, Holger Wallbaum

Highlight

Aiming to improve the quality of life for living, learning, curing and working in future intelligent buildings in terms of offering advanced indoor built environments, which takes advantage of reliable and supportive technologies, and is rooted in evidence and resilient design thinking and human real demands targeting human health and wellbeing along with low environmental impact and high economic performance over the whole building lifecycle.

Scope

Considering "health and wellbeing" in intelligent buildings, ecologically sustainable design, indoor environmental qualities, smart metering and control strategies, energy efficient technologies as well as user demand are interrelated closely. This chapter discusses the key features for human health and wellbeing in buildings as well as research gaps between the real perception from user side and the measured building performance. Key research questions are put forward that need to be answered. Research and development concerning knowledge, tools and technologies are initiated. Finally, new horizons for the future built indoor environment of intelligent buildings are depicted.

3.1 Status quo

Looking back on the progress of intelligent buildings since the year 2000, the content of quality of life and users' interactions have been being taken into play as one of the evolutionary strategies. Quality of life makes contributions to the key performance indicators of social well-being and economic efficiency and the specific visions of human health and well-being are one of the key criterions in intelligent buildings' classification. Particularly in next generation office buildings, user-oriented lower carbon footprint, and resilient office design solutions are to be implemented for future. A circular design process instead of conventional linear design is created to holistically integrate multidiscipline and diagnose the real demand from users and stakeholders during the whole building lifecycle [Cobaleda Cordero et al., 2018].

Human health and wellbeing are more commonly known as a positive factor to human productivity in particular for offices [Wargocki et al., 2000; Fisk, 2000]. Productivity is one of the key drivers taking the utmost benefits to building stakeholders. High work productivity of the employees and less sick leave absences could be seen as a game-changer in future intelligent buildings and sustainable office buildings [Feige et al., 2013]. If we contribute to reducing the staff costs in the operational phase through energy efficiency measures and a better indoor environmental quality (IEQ), then we can argue for higher investments on energy efficient and innovative technologies as well as human wellbeing. It has been concluded that if only 10% variation is made by our effort from staff costs, 9% cost saving can be realized in total during the operation phase of buildings (see Fig. 3.2).

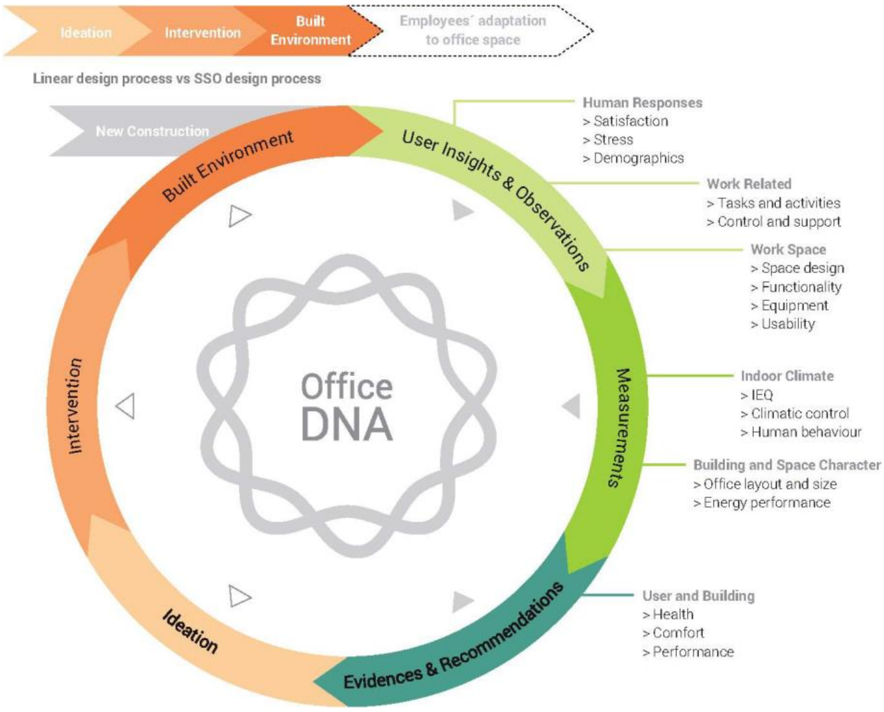


Figure 3.1. Linear design process vs circular SSO design process [Cobaleda Cordero et al., 2018]

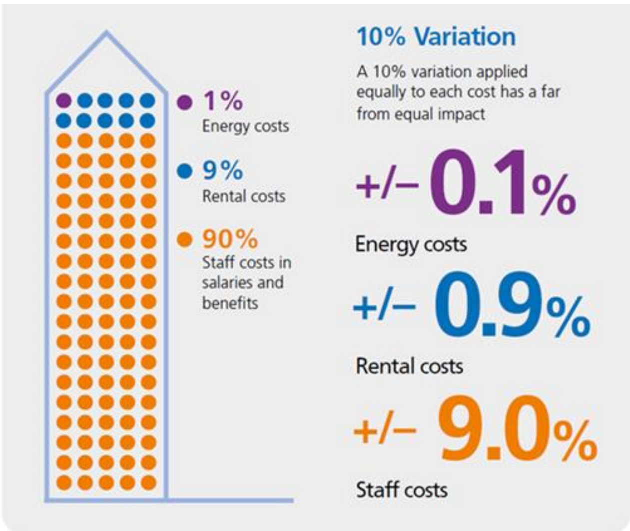


Figure 3.2. Typical business operating costs regarding energy, renting and staff. Source: Health, Well-being & Productivity in Offices, World Green Building Council, Sept. 2014 [WGBC, 2014]

There are more and more indications that a good IEQ in office buildings positively contributes to the well-being of occupants, reduces sick leave days and finally, leads to an increased productivity [MacNaughton et al., 2018]. These so-called co-benefits could be seen as a driver for more energy efficient and healthier buildings in the future - saving costs for both businesses and the society. When concerning the other way round, the consequences of occupant discomfort and ill-health caused by bad IEQ finally can lead to low work performance and more sick leaves. IEQ in terms of thermal climate, air quality, acoustic and lighting and daylights have a noticeable impact on human comfort, health and productivity which have been selected as mandatory indicator listed in sustainable building rating systems, e.g. WELL, GREEN STAR, BREEAM, LEED, DGNB, Miljöbyggnad, GBI. IEQ needs to be designed and optimized to maximize human well-being and productivity. But sometimes the building design may not create a better indoor comfort and one of the reasons is that we lack of an interdisciplinary study and the cross-disciplines knowledge frame from the physical climate, architectural design, organization environment, as well as social and cultural background of the users.

Beyond IEQ, the other disciplines regarding ergonomic interior design, space function and flexibility use, new user behaviour patterns and work demand need related aspects have been considered [Schiavon & Altomonte, 2014; Kim & de Dear, 2013]. In different building typologies, e.g. offices, apartments, schools, health care centres, elderly home, the specific living and working environments needed from different groups of users should be customized and used for a convenient and efficient living in intelligent buildings. Up to now, the interrelation and interaction of different factors are far from clear, hense a holistic and evidence based design and optimization in future intelligent buildings is exceedingly demanded.

To generate knowledge on buildings and users and their interactions, fundamental studies [de Dear et al., 1998; Zhang et al. 2010] have been conducted on exploring the mechanisms of how humans perceive the indoor environment, what are preferred indoor environment, and what are the key indicators regarding both physiological and psychosocial aspects, for example, skin temperature's reaction to thermal comfort's change and gender's differentiation on the preference [Jin et al., 2016]. Based on new knowledge explored in intelligent buildings embedded smart sensors, meters and automation systems with the human physiological condition, behavioral data and building performance monitoring and information communication technologies have been being extensively applied. An outcome is to match human real demands, preferences and changing behavioural patterns with responsive and adjustable indoor environments and low energy use through intelligent control strategies, for instance, smart grid and demand response control.

Nevertheless, health and wellbeing are more complex on the mental and perceptual levels than it can be predicted only based on the results of measurable building performance parameters [Bluyssen et al, 2011]. There are still many knowledge gaps concerning human real demands and the designed indoor built environments such as a comprehensive understandings of how various factors affecting health and wellbeing, what are the biases existing between human real demand and building performance, etc. However, existing datasets are still limited to identify all related factors and quantify the influencing relations to truly achieve sustainable indoor built environment in different typologies of intelligent buildings. Obviously, there is a demand to gather sophisticated information on occupants' perception and behaviour as well as various building performance related aspects such as energy efficiency levels, the role of smart materials, and potentials of smart technologies. This demand is seen globally but a localisation is required to adequately address socio-economic and cultural differences.

3.2 Research and Development

Global database development: Data collections on energy performance, IEQ and occupant health and wellbeing from existing and new buildings need to be conducted further towards a cutting-edge database set up concerning climate, social and economic conditions. The database development will be a crucial bridge to conquer the gaps between human demand and building performance. More concerns will lie on the data from occupant perceptual and real-time indoor comfort and health, user behaviour and preference, measured energy performances, and from building features on building typologies, user information, indoor environmental qualities, interior components and landscape and low-carbon technologies.

Information communication technology (ICT) embedded data collection and internet of things (IoT): A long-term and longitudinal data collection process is to be promoted to help to visualize the mega field data as "right here, right now" with detailed insights to a dynamic indoor climate and human demands. Embedded ICT equipment and system will allow an intelligent and distance monitoring of various building technologies and equipment. IoT will implement much smarter ways to connect personal equipment and device according to individual preferences of comfort and cost and energy consumed concerns allowing communications between smart meters and smart grid, such as the adjustable orderings of personal heaters, windows, self-ordering fridges, washing machine at low energy tariff times, and surplus energy back to the grid.

Insights tools and analysis platform: Advanced and instant qualitative and quantitative insights tools to collect occupant responses on comfort, health and wellbeing are to be developed integrating different expertise of engineering, architecture, psychology, physiology, etc. A web-based platform to visualize instant data collected will efficiently transfer building performance and occupant real demand to building stakeholders and provide recommendations for building service systems and human behaviours.

Sustainable technologies for advanced indoor environments: Intelligent buildings should be better featured by human-oriented built environment design and environment-friendly indoor climate technologies. When considering to improve human health and wellbeing, more sustainable technologies regarding energy efficient building design, low impact construction and ergonomic services should be identified and applied to provide advanced indoor climates achieving a higher sustainability performance.

3.3 Future Horizons

- Health, wellbeing and low energy use based indoor environment design will be tailored for different groups of end users regarding building typology, personal comfort profile and office "DNA". A holistic understanding of the factors existing in buildings and from the user perspective will be generated in depth to promote a knowledge evolution on the conceptual creation and strategic plan in future intelligent building development and construction.

- Human real demand to be fulfilled by reliably smart technologies and resilient indoor climates with "surplus energy" balance. Long-term monitoring of indoor environment as well as human behavior and occupant feedback gathering systems will be commonly embedded in the future buildings to fully access the real-time information and conduct artificial intelligence analysis with the big data collection.

- Maximize the benefits through social, environmental and economic dimensions when creating a living environment for humans. The added values of improved comfort, health and productivity will be further quantified and emphasized compared to the mere energy perspective in future buildings aiming for a better sustainability. New indicators and indices will be developed to sophisticatedly evaluate the performance of the next generation of intelligent buildings.

> Chapter 3 aims to emphasise human health and wellbeing in indoor environments for future intelligent buildings along with low environmental impact and high economic performance over the whole building lifecycle. Quality of life makes contributions to the key performance indicators of social well-being and economic efficiency, and the specific visions of human health and well-being are one of the critical criterions in intelligent buildings' classification. Particularly in next-generation office buildings, user-oriented lower carbon footprint, and resilient office design solutions are to be implemented for future.
>
> This chapter discusses the key features of human health and wellbeing in buildings as well as research gaps between the real perception from the user side and the measured building performance. Fundamental research questions are put forward that need to be answered. Research and development concerning knowledge, tools and technologies are initiated. Ultimately, new horizons for the future built an indoor environment of intelligent buildings are depicted.
>
> The highlight of the conclusion is offering advanced indoor built environments for the future building users, which takes advantage of reliable and supportive technologies, and is rooted in evidence and resilient design thinking and human real demands. A circular design process instead of conventional linear design should be utilised to holistically integrate multidiscipline and diagnose the demand from users and stakeholders during the whole building lifecycle. Future R&D activities are needed as global database development, ICT embedded data collection, as well as sustainable technology implementation for advanced indoor environments. In a nutshell, we anchor three horizons: health, wellbeing and low energy use based indoor environment design, fulfil human real demand, as well as maximize benefits of living indoor through social, environmental and economic dimensions

References

Bluyssen P. M., Janssen S., van den Brink L.H., de Kluizenaar Y. (2011). Assessment of wellbeing in an indoor office environment, 46 (12): 2632-2640.

Cobaleda Cordero A., Rahe U., Wallbaum H., Jin Q., & Forooraghi M. (2018). Smart and Sustainable Offices (SSO): Showcasing a holistic approach to realise the next generation offices. Informes de la Construcción, 69 (548): e221.

de Dear, R.J., Brager, G.S. and Cooper, D. (1998). Developing an adapting model of thermal comfort and preferences, ASHRAE RP-884 final report. Atlanta: American Society of Heating Refrigerating and Air Conditioning Engineers.

Feige Annika, Wallbaum H., Janser M. & Windlinger Lukas. (2013). Impact of sustainable office buildings on occupant's comfort and productivity. Journal of Corporate Real Estate, 15(1): 7-34.

Fisk, W.J. (2000). Health and productivity gains from better indoor environments and their relationship with building energy efficiency, Annu. Rev. Energy Environ., 25, 537–566.

Jin Q. & Duanmu L. (2016). Experimental study of thermal sensation and physiological response during step changes in non-uniform indoor environment. Science and Technology for the Built Environment, 22(2), 237-247.

Kim, J. and de Dear, R.J. (2013). Workspace satisfaction: the privacy-communication tradeoff in open-plan offices. J Environ Psychol, 2013, 36:18-26.

MacNaughton P., Cao X., Buonocore J., Cedeno-Laurent J., Spengler J., Bernstein A., and Allen J. (2018). Energy savings, emission reductions, and health co-benefits of the green building movement. Journal of Exposure Science & Environmental Epidemiology. (online published).

Schiavon, S. & Altomonte, S. (2014). Influence of factors unrelated to environmental quality on occupant satisfaction in LEED and non-LEED certified buildings. Building and Environment, 77, pp. 148-159.

World Green Building Council. (2014). Health, Well-being & Productivity in Offices_ the next chapter for green building. Retrieved from http://www.worldgbc.org/news-media/health-wellbeing-and-productivity-offices-next-chapter-green-building.

Wargocki P., Wyon D.P., Sundell J., Clausen G., Fanger P. (2000). The effects of outdoor air supply rate in an office on perceived air quality, sick building syndrome (SBS) symptoms and productivity. Indoor air, 10(4): 222-236.

Zhang H., Arens E., Huizenga C. & Han T. (2010). Thermal sensation and comfort models for non-uniform and transient environments, part II: Local comfort of individual body parts. Building and Environment, 5(2): 389-398.

4. Technology Aware Workplaces

Matthew Marson

4.1 Introduction

Often, with intelligent buildings, it is found that lots of technology is implemented for the sake of technology – a demonstration of technical prowess. The vast majority of the systems implemented are for energy management. For knowledge-based industries, energy accounts for only 1% of the operation costs, yet real estate costs account for 9% and employees' salaries and benefits account for 90% (JLL, 2017). Therefore, human-centric design is, in fact, a more appropriate way to design use cases, select technologies and operate a building, helping businesses to achieve their wider outcomes.

Globally, workplace design is being increasingly important and relevant to business outcomes (Morgan, 2017). By being culture-centric, a business can demonstrate a key differentiator in a market of homogenised remuneration packages.

Noteworthy workplaces often feature fully integrated suites of technology. Having workplaces that are adapted in real-time*, using technology*, allows a business to reduce the productivity leakage of their workforce. Productivity leakage is the sum of all the pain-points that an employee experiences during the day that prevent them from doing something productive. This could include a faulty coffee machine, waiting for an elevator or voice-over IP technology that repeatedly fails. Sodexo believe that most white-collar workers experience around two hours of productivity leakage a day. For most businesses, this means that 25% of the working day is lost due to workplace inefficiencies. This represents a significant cost to the business. This paper will outline some examples across the below three value levers:

1. The Change Role of Technology in the Workplace
2. Wellness & Productivity
3. Social Collaboration & Space Optimisation

4.2 The changing roles of technology in the workplace

As robotic automation replaces the jobs of those doing repetitive tasks, the workforce of the future will be performing tasks that leverage non-automatable skills such as creativity, communication, innovation or collaboration. Often, workplaces are designed for a single person to sit at a single desk. This kind of design restricts fluid ways of working. The fundamental technology delivered in the workplace will become more consumer grade and more flexible and mobile than ever. Those working across geographies or from co-working or café spaces need enterprise technology that is as malleable as the expectations of a person performing a role.
The workplace is becoming more of a destination. IBM, the company that championed telecommuting for the vast majority of its history, is now recalling its staff to the office. The company believes that their employees need face-to-face interactions in order to develop their products and services, as well as be more engaged.

New methods of business such as a design thinking and agile development need different types of spaces and technologies. Design thinking requires collaboration rooms for sticky note activities. Agile development needs ceremony space with audio-visual equipment that can demonstrate a software product. This means that the technology provided in the workplace needs to be integrated into the fabric of the building, in the fabric of the organisation and be well integrated to reduce support over-heads and productivity leakage.

4.3 Wellness & Productivity

The optimisation of the physical environment goes hand-in-hand with the productivity of the employees and their health and wellbeing (Stoddard, 2016). Delivering a technology empowered wellness programme to the workplace can help a business reduce its employee's sick days by 28% (ERS Research & Consultancy, 2016).

For example, by having a set of sensors linked to an Internet of Things (IoT) platform, it is possible to automate the control of internal air quality. In a meeting rooming, it is possible to observe the levels of CO_2 increase over time. When CO_2 levels in a space are too high, the ability to make decisions and to concentrate plummets (RESET air, 2016). By comparing the rate of CO_2 production with the occupancy (gathered from a mesh of quad-pyro passive infrared sensors) from a connected lighting system and the design values of the space, machine learning can be applied to control the volume of fresh air being delivered to that space. This way, the building can autonomously keep the internal air quality as healthy and productive as possible.

The industry is also seeing the growth in demand for circadian lighting. Circadian lighting has two main types. The first type 'daylight harvests'. This means that it only adds synthetic light in addition to what natural light is not providing. The driver for colour temperature is still the sun. The second type of circadian lighting synthetically controls the colour temperature to mimic the sun. Both have been shown to be far less disruptive on a person's circadian rhythms. Technology can also be implemented on occupant's laptops and phones that make the back light of the device follow the circadian rhythm. This means that the employee is able to get to sleep naturally and is therefore more productive the following day. This use case combined both energy efficiency and health for the business imperative.

Productivity leakage can also occur through the lack of availability in concierge-type services. The ability to ask simple questions with an emotional touch helps employees to be more effective when dealing with organisational policy. Today, we are seeing customer services organisations implement artificial intelligence chatbots to deal with high customer demand. This significantly reduces the operational overhead whilst delivering a sentiment-based response. Fjord believes that artificial intelligence will be the user interface of choice in the future. By implementing this kind of technology in a building, employees will be able to adjust room settings, find available spaces on the fly, check the status of requests and much more. We will the growth in the concept of building service user interface in line with consumer liquid expectations.

Beyond voice, video will also be used to measure the sentiment of employees. Linking a series of cameras to a video analytics platform will analyse the facial expression and postures of employees to understand their mood. This means that the building can intelligently adapt the surroundings to increase comfort. Perhaps when it looks like someone is having a bad, the building could reward them with an increase. These sorts of ludic or delight events inspire employees and keep them engaged.

4.4 Social Collaborations & Space Optimisation

The management of space can often cause dissatisfaction in the workplace. The ability for employees to query real-time utilisation data, means that they can make decisions on where to go for some focused time, or a private call. They can also make an intelligent decision on when it is good to go to the canteen. Being able to expose this data in a user-friendly way is often a challenge for real-estate departments.

Knowledge workers rely on the knowledge of others. In large organisations, the ability to connect and speak to others is often achieved through social knowledge as corporate directories are often hard to navigate and do not relate to the physical world. Implementing a set of location services in a building allows a culture of collaboration to be achieved. Today, if you need to find someone with analytics skills for the project that you're working on requires you to email someone that may know someone. Before you know it, you have been passed through tens of connections. By integrating the location of employees (through WiFi triangulation or a Bluetooth beacon enabled mobile app) to a skills database, means that colleagues can now connect faster with those in the same building. This reduces productivity leakage and increases interdisciplinary interaction. For businesses wishing to be more innovative, the building can force social collisions by displaying interesting information about those in the immediate vicinity to start a conversation.

This sort of technology often creates privacy concerns. By ensuring that the employee has to opt-in into different levels of privacy, means they are more forthcoming with the vision. By limiting the display of data to back-end, the front-end, then biometric systems, employees are able to expose as much or as little data as they are comfortable with. The ability to switch on and off on demand is an import control that makes the populous feel more comfortable.

Location services can also be leveraged to reduce productivity leakage by giving the ability for employees to rapidly find a thing (such as a high-value or well-used piece of equipment). This allows an organisation to make better use of scarce resources and maintain assets properly. It also allows individuals turn-by-turn navigation to parts of the building that they are unfamiliar with. This helps visitors and temporary employees get their bearing within a building.

4.5 Summary

The clear majority of the use cases above can only be achieved through comprehensive integration of legacy and additional systems throughout the building.

Traditional building management systems are not sophisticated enough to deal with the number of integrations, or computations. Having a connection to a cloud-based IoT platform, means that buildings can have new applications installed to unlock enhanced automation or other use cases.
As the line between the physical and the digital continues to blur, we will see the increase in technology in the workplace.

References

Clements-Croome, D. (ed.). (2018). Creating the Productive Workplace: Places to Work Creatively. 3rd edn. London & New York: Taylor & Francis.

ERS Research & Consultancy (2016) Health at Work: Economic Evidence Report 2016, Milton Keynes.

JLL (2017) Workplace Powered by Human Experience, New York.

Morgan, J., (2017) The Employee Experience Advantage: How to win the war for talent by giving employees the workspaces they want, the tools they need, and a culture they can celebrate, Hoboken:Wiley.

Stoddart (2016) The Workplace Advantage – The 20 billion key: why the office environment is key to productivity, Review report, London: Raconteur. https://www.raconteur.net/the-workplace-advantage.

5. Daylight in Intelligent Sustainable Architecture

Juergen Koch

5.1 In general - Daylight and its Importance:

Daylight is the basis of all life and growth. It controls our organism and has a significant influence on our health, performance and well-being. Daylight serves not only to see, but gives us spatial orientation, orientation to the time of day and season because orientation is essential for our well-being as well.

Being without orientation is a terrible condition that can be caused by illness or is generated by external circumstances for that architects and engineers sometimes are responsible for. The sun can be used for heating our buildings as well.
Winter gardens or roof glazed atriums are excellent examples as so called climate puffers.

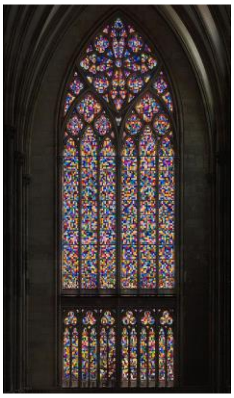
Daylight is, however, also the most natural free resource.
Why we don’t use it more intelligent in architecture is incomprehensible and irresponsible.

5.2 "Daylight cannot be replaced by anything"

How do we use daylight in commercial architecture today?

What is the “status quo”?






Historic Daylight Architecture - Cologne Cathedral *Seagram Building New York City 1958*

Architects and inhabitants has always the dream of buildings having a clear and wide view into the environment and nature and at the same time being protected from the elements. With the development of even better and larger glazing’s, this dream came true after World War II since the middle of the last century. The famous architect Mies van der Rohe was one of the protagonists in "Bauhaus" architecture and masters of reduction to the essentials. The Seagram Building (1958) in New York City is one of the most famous skyscrapers representing this dream. But Gothic cathedrals show the fascination of daylight and large glazing’s as well centuries ago.
More daylight in architecture was the reaction to the narrow, dark and unhealthy housing conditions that with the first industrial revolution led to inhuman conditions in rapidly growing industrial cities.

With large glass surfaces are not only benefits came up. Direct solar irradiation over large glass surfaces also leads to glare of the occupants and to overheating the interiors. Internal glare protection and air-conditioning systems have to heal the deficiencies of our buildings with a huge energy input.
By the mid-seventies of the last century, oil was cheap and no one was looking for more intelligent solutions. Glass industry and refrigeration industry became very good friends from that times.

In many commercial buildings the cost of HVAC rose to 40% of the total construction costs. Despite these problems, large-scale glazed buildings have not lost their fascination to this days. „The dream is still awake.“ But we have to solve the problems so that the dream does not become a nightmare.

It was first the oil crisis in 1972 and the publication of the Club of Rome report,
"The Limits of Growth," which led to a trend reversal.

Initially, architectural concepts were developed in housing construction, which attempted to make climate-friendly residential buildings with passive natural resources. Winter gardens, which captured the heat of the sun for heating purposes, became modern again. But in commercial buildings, little has changed as far as the intelligent use of sunlight is concerned. So far, we have come up with no better idea than shielding the glare and turning on the artificial light when the sun is shining. With some luck, the caretaker turns off the lights at night. In many commercial buildings artificial light burns all night until morning. This is absolute nonsense and is the opposite of intelligent buildings.

So the answer to the question how we use daylight in commercial architecture is:
We use it just a little and that in a stupid way. This is totally crazy and quite primitive compared to the automotive industry for example or the digitalised world in other areas. The internal sun protection/blinds can only be used as glare protection. The solar heat still reaches the rooms and causes cooling. That means, sunlight causes energy need. It should be exactly the other way around.
It is time to use sun and daylight more intelligent for our buildings and cities7public areas.

Daylight Architecture is one of the most intelligent ways to use free renewable energy and increase comfort, health and well-being in our buildings and by the same time reducing carbon emission.


“Spherion” Deloitte’s German Green Corporate Daylight Architecture - Best Office & Office of the Year 2014-Green Building



5.3 What can be done better to use the sun and daylight more intelligent?

Using daylight and the sun more intelligently not only means better light quality, health, comfort and well-being for the user, but also a reduction in heating and cooling requirements and the associated waste of energy and at the same time reducing CO_2 emissions.

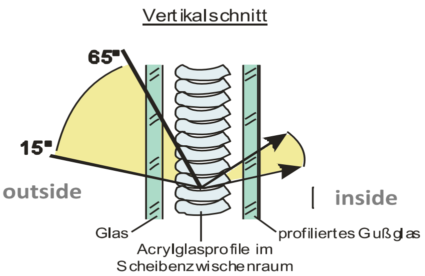
We have to control the daylight in a better way so that less heat enters the interior. Integrated blinds in between of triple glazing can, for example, be a good solution. However, since daylight is not constant, but constantly changing, intelligent buildings must react to it automatically. By the same time the blinds are closed a part of the daylight reaching the window should be used intelligent. This means that modern facades and conservatories should respond to weather conditions, sun exposure and intensity and changes in the use of the building.

The components are:

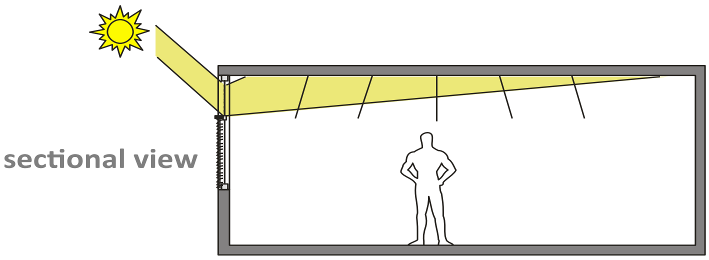
1. Daylight redirection elements.
2. Efficient electrical sun- and glare protection system.
3. Control system which regulates the sun protection system automatically.
4. Sensor-controlled LED lighting, which reacts automatically on the daylight offer.
5. One or two weather stations on the roof of the building.
6. A clever person who writes the program for the control system.

To control the blinds a program has to be written that is adapted to the building, its use and its natural and social environment.

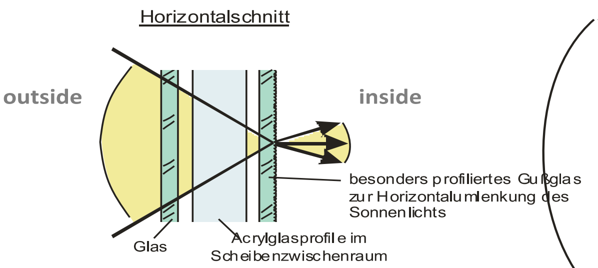
This system is not really complicated, but it is complex. It reduces the power requirement for lighting up to 25%. At the same time it ensures that less cooling and heating is required. This means, of course, that the control system must be connected to the overall building control system as well. The areas that are supplied with natural healthy daylight can be doubled. In this case, improving comfort, well-being and health of employees means that the productivity of employees in these buildings is much better.



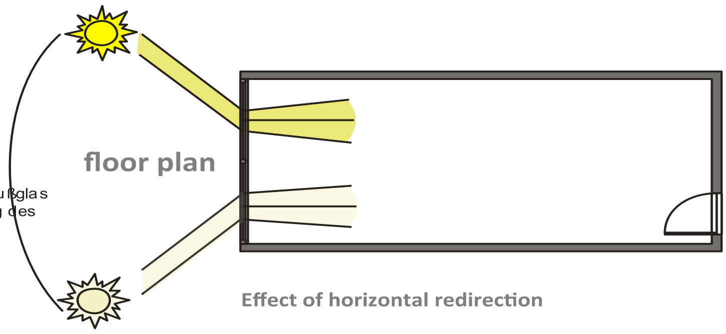
Operation mode vertical redirection



Effect of vertical redirection

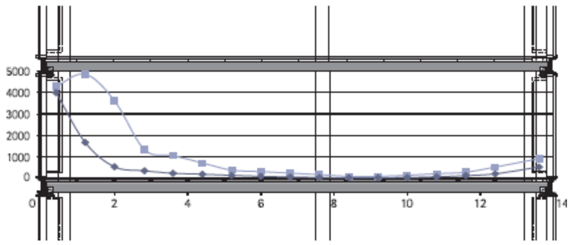


Operation mode horizontal r-derection



Effect of horizontal redirection

Daylight redirection combined with sensor-controlled lighting



lux - lower line without redirection, *traditional shading* *with innovative daylight*

above line is with redirection

daylight redirection with closed blinds *daylight redirection with open blinds*

5.4 Conclusion:

Why we do not more of these? Are there industrial interests blocking new technologies? To design und realise more intelligent green and sustainable buildings does not mean to put on something on traditional construction methods and systems to make them more expensive, it is about to change something in the process of planning and to integrate and cultivate new technologies in our architectural design language. It is called IED, Integrated Energy Design. That means for example, the quality and functions of façades are becoming of more importance and connected holistic systems are required instead of the traditional addition of separate systems. But it also means, that the money for construction is moving from the old technical centres into the outer skin of sustainable intelligent buildings.

In commercial buildings of course are other and additional ways of using daylight than in facades are recommended, like roof lights. But that means for example for supermarkets, to control the incoming light as well but in a generally similar way as in facades.

It is all about connecting and combining different systems to control the daylight in our buildings and our buildings must be able to react on changing weather- and use conditions. The panning instruments have to consider different dynamic processes over the year, so we use dynamic simulation programs optimising the relationship between buildings and the changing environment conditions, like in a living organism.
The dimensioning of technical aggregates, based on worst case conditions, is of the past.
It is about optimisation and using synergies to get more intelligent buildings.

Worldwide 1st new generation of daylight and carbon neutral Supermarket in Berlin

But one thing always has to be considered first, people. People should always be in the focus of everything that architects and engineers do. It's not about what's technically possible. We need to be careful not to get over-engineered buildings, we need robust and resilient solutions because human habits in building use are different and are not a constant factor in all engineering calculations, as the computational models often suggest.
Buildings and their technical systems need to be intelligent, but also easy to handle.

Daylight Architecture is one of the most intelligent ways to use free renewable energy and increase comfort, health, well-being in our buildings and reduces carbon emissions, hopefully soon.

We have to use daylight in commercial buildings more intelligent by controlling the daylight so that less heat enters the interior. Daylight redirection combined with integrated blinds in between of triple glazing, for example, is a good solution. However, since daylight is not constant, but constantly changing, intelligent buildings should react to it automatically, like in a living organism.

That does not mean to put on something on traditional constructions to make them more expensive. It`s about to change the planning process, to integrate new technologies into our architectural design and using synergies. It’s called IED, Integrated Energy Design.
The quality, complexity and functions of facades are becoming more important and connected holistic systems are required to control the daylight, artificial light, heating, cooling and ventilation. Dynamic simulation programs can help to optimise the relationship between buildings and the environment.

But one thing has to be considered first, people should always be in focus of everything that architects and engineers do. It's not about what's technically possible.
Around the country we need better legal regulations regarding minimum distances between buildings related to their height, so that architects and engineers get the chance to use the sun more intelligent for well-being.

We also have to be careful not to get over-engineered buildings, we need robust and resilient solutions because human habits are not a constant factor in engineering calculations, as computational models often suggest. Buildings need to be intelligent, but also easy to handle.

Controlled daylight use in buildings is one of the most intelligent ways to use free renewable energy and increase comfort, health, well-being in our buildings and reduces carbon emissions, hopefully soon.

6. Intelligent Infrastructure

Mark Worall

6.1 Conceptual framework:

Buildings are one of the priority areas for tackling urbanisation issues through smart city initiatives (Airaksinen, *et al*, 2016). Intelligent buildings will play major roles in tackling energy, resource and environmental issues and the intelligent buildings roadmap will set out many of the challenges facing the sector, but also opportunities for advancement. However, intelligent buildings developed in isolation will not be able to fully address the challenges and will therefore not in of themselves provide optimal solutions.

Figure 6.1. Buildings, the city and its infrastructure

Buildings are a part of a complex ecosystem that displays many of the features of living organisms (Nilon, *et al*, 2003) – flows of energy and matter, flows of information, interaction with the environment, rhythm, growth and decline and evolution. Historically, buildings and the infrastructure connecting it to other buildings and services have had no interaction apart from such one way processes such as metering and billing.

If buildings are seen not as individual entities, but as dynamic components in that ecosystem, then "intelligent infrastructure" should be considered as the distribution system connecting individual intelligent buildings in a multi-faceted, interactive network.

Infrastructure connects buildings to the wider community through networks that have functions as diverse as the supply of services such as electricity, fuel, water and communications, the removal and treatment of waste such as sewage and refuse, and the movement of commuters through road and rail networks.

Buildings have a wide variety of uses, ranging from residential dwellings, office and commercial buildings, retail, catering and leisure centres, public buildings such as schools and hospitals, factories, warehouses and distribution centres and data centres and server buildings. The wide range of services networking with buildings and the diverse range of building type and usage pattern means that intelligent infrastructure can allow individual buildings to operate whilst the infrastructure enables the system as a whole to be optimised.

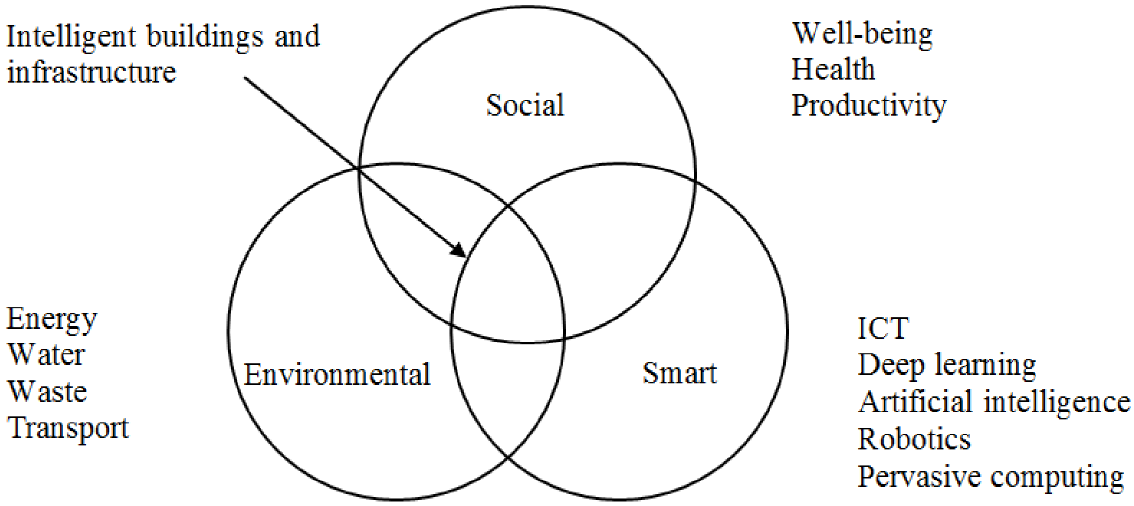


Figure 6.2. Diagram indicating the interrelationship between social, environmental and smart elements that defines intelligent buildings and infrastructure.

Intelligent buildings and infrastructure enables buildings to be productive and cost-effective environment based on three basic intersecting elements;

- social
- smart
- environmental

Social
We spend over 80% of our time in buildings (Klepeis *et al*, 2001) and the needs and desires of people manifests itself in demand for services and consumption of resources. Developing intelligent buildings and infrastructure that respond the people's needs will contribute to well-being whilst addressing the capacity of the environment to meet these needs in more sustainable ways.

Smart
Infrastructure is becoming connected through advances in information and communication technologies (ICT). Internet connected sensors and devices are becoming more and more available and it is projected that there will be over 26 billion connected devices by 2020 (Evans, 2011). Recent advances in areas such as complexity modelling, data mining, deep learning, AI, and the internet of things (IoT) could enhance the drive to more efficient use of resources and the optimisation of buildings and the infrastructure serving the needs of people. These developments present many challenges, but also opportunities for advancement (El-hawary, 2014).

Environmental
Buildings use up to 40% of the world's energy resources, around a third of carbon dioxide emissions and 10% of water withdrawals, so the provision of electrical power, heat, water and waste are important for developing sustainable building services. Until recently there has been a one way relationship; energy and water was delivered and waste was removed; but the advent of smart grids and intelligent networks is meaning that the management of resources is becoming more dynamic and responsive. Two of the main services vital to buildings and the people using them are energy and water. Energy and water are inextricably linked. Water is necessary for power

generation and energy production and energy is needed for water extraction, processing and delivery and this interconnectedness is sometimes referred to as the water-energy nexus. Intelligent infrastructure will integrate the production and distribution of energy and the provision of water and waste services.

6.2 State of the Art

Social infrastructure

Challenges

- *Health*: As urban population density and GDP increases, energy consumption, water demand and transport use will increase. The health, safety and well-being of people, especially vulnerable sections of society such as children, the elderly and people with underlying health conditions will be harmed due to increases in pollution, emissions and inadequate sanitation. The infrastructure connecting buildings to its services will need to balance the demand for services with the needs of people for good health.
- *Wellbeing:* The WHO states: 'Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity'. The term 'well-being' reflects one's feelings about oneself in relation to the world. Many issues contribute to health and wellbeing either positively or negatively, and intelligent infrastructure can contribute to good outcomes and mitigate poor outcomes.
- *Employment:* Intelligent buildings as workplaces, provide environments in which people perform tasks in a productive and cost effective manner, but in which their well-being is not just an afterthought, but is part of the process. However, the development of automation, robotics and artificial intelligence (AI) could see the loss of jobs over a wide range of occupations. Frey and Osborne (2017) predict that up to a half of total US employment is at high risk of being replaced by computerisation and automation.
- *Job losses*: Buildings designed to support sectors vulnerable to computerisation (low skilled, low wage sectors) would be surplus to requirements and would need to be modified in order to cater for newer job categories, converted to other uses, left unoccupied or be demolished. This would present challenges to;
    - The owners of buildings, due to the loss of revenues over a building's lifetime, costs of conversion to new use, or costs of demolition and rebuild.
    - The users of building in emerging job categories, should buildings not be fit for purpose, which could lead to frustration, reduced job satisfaction and lower productivity.
    - Architects and urban designers, due to the need to refurbish existing buildings or creating new buildings suitable for emerging job categories.
    - The urban landscape, as cities are transformed (in either planned or unplanned ways) due to the modification of existing buildings, the creation of new buildings or the abandonment/demolition of obsolete buildings.
- *Fragmentation*: If alternative employment or new job categories do not emerge to replace the ones lost to computerisation or adequate re-training (social infrastructure) is not made available, then society could fragment into sections that have the skills and capital to exploit the new technologies and those that do not.
- *Urbanisation:* Well-being is a complex concept that includes job satisfaction, a good work-life balance, stimulation of the mind, interaction with nature, health, wealth and happiness. As urbanisation increases due to economic and population growth and the stresses of living and working in cities rises, individual and societal well-being is in danger of being undermined.

- *Green spaces*: as infrastructure develops to meet the needs of cities, natural spaces, such as parks, gardens and playing fields are in danger of being lost to buildings, roads and pavements. A positive relationship between green outdoor spaces and levels of stress in the workplace has been found (Lottrup *et al* 2013). The well-being of the occupants of buildings will suffer with a decline in natural spaces. This will result in reduced performance at work, increased signs of ill-health, such as absence from work, an increase in sickness levels, reduced retention rates for good staff and a higher turnover. This will have an adverse economic effect to employers, who will have to compensate for reduced productivity and output.

Opportunities

- *Adaptability:* Intelligent buildings should be designed to be adaptable and reconfigurable, so that they can meet the challenges of changing work patterns, but intelligent infrastructure presents important opportunities for bridging the gap. For instance, heat networks can provide thermal energy to buildings, but if the energy usage changes with work patterns, then adjustments can be made at the infrastructure level, saving investment costs in individual building HVAC plant.
- *Better jobs:* Many of the repetitive, tedious, physical and mentally stressful jobs currently carried out by people will be computerised, enabling many to pursue more interesting careers, thus enhancing personal well-being.
- *New jobs:* New employment opportunities will be created by computerisation, which may more than offset the jobs lost.
- *Economic growth*: cities are engines of economic growth (80% of global GDP) due to the concentration of diverse pools of labour and the ability of people and businesses to share information and knowledge (UN DESA, 2015).
- *Economies of scale*: investment in physical (roads, pipelines, cables) and social infrastructure (education and health) is more effective in cities than in rural areas due to economies of scale (UN DESA, 2015).
- *Green spaces*: as infrastructure develops to meet the needs of cities, natural spaces, such as parks, gardens and playing fields are in danger of being lost to buildings, roads and pavements. A positive relationship between green outdoor spaces and levels of stress in the workplace has been found (Lottrup *et al* 2013). The well-being of the occupants of buildings will suffer with a decline in natural spaces. This will result in reduced performance at work, increased signs of ill-health, such as absence from work, an increase in sickness levels, reduced retention rates for good staff and a higher turnover. This will have an adverse economic effect to employers, who will have to compensate for reduced productivity and output.
- *Health*: As urban population density and GDP increases, energy consumption, water demand and transport use will increase. The health, safety and well-being of people, especially vulnerable sections of society such as children, the elderly and people with underlying health conditions will be harmed due to increases in pollution, emissions and inadequate sanitation. The infrastructure connecting buildings to its services will need to balance the demand for services with the needs of people for good health.
- *Commuting*: Computerisation may reduce the need for commuting as more people may be able to and be happy to work from home or in non-office environments.

Smart infrastructure
Challenges

- *Security concerns:* vast quantities of data are shared between buildings and networks, so systems are vulnerable to cyber-attack. Encryption and other security measures ensure that most transactions are safe and secure, but weak points can be exploited that allow access to sensitive data and leaving individuals or organisations vulnerable to attack. Financial resources, intellectual property and organisational security can be compromised.
- *High initial costs:* infrastructure requires physical (or virtual) connections between buildings, networks and suppliers, so costs of installation in laying cables, pipework and ducting may be substantial.
- *Fear of obsolescence:* information technology and smart devices are developed rapidly, but often superseded or upgraded in relatively short periods of time. Therefore, there are fears that investment in “intelligent infrastructure” or other “smart” technologies may be a waste of money as the technologies become obsolete.
- *Disconnect between user and the technology:* pervasive computing, in which user friendly interfaces, such as voice recognition software and virtual assistants, are removing the barriers between users and services to produce a seamless, intuitive environment. As users become less familiar with the way that the underlying technology is operating, they will be less aware of potential problems. Users will then be relying on regulating authorities or experts to hold the technology operators to account.
- *Interoperability:* vast volumes of data are processed from a wide variety of sources, with different software and communication protocols. If sources and networks cannot communicate, then AI will be less effective. Many organisations at the forefront of AI development use proprietary systems that are not interoperable with other systems.
- *Privacy:* as data are constantly being generated and analysed from intelligent buildings, intelligent infrastructure and the people that use them, there are many concerns that personal and organisational information that is currently protected by privacy laws will be available to third parties, whether they be employers, governments, political organisations, advertisers or criminals. If individuals or organisations do not have confidence that the data generated will be used responsibly, then there will be resistance to the take up of smart devices, which in turn will reduce the effectiveness of the system.
- *Personalised services:* AI and data analytics now have the ability to create personal profiles from the data generated, which can help companies to target advertising to specific groups and provide information on political and social interests to lobbyists and polling organisations. Many of the services provided are useful and benign, but many could infringe on people’s right to privacy. Balancing the right of data analytics organisations to masses of data and the right of an individual or an organisation to privacy is a vitally important challenge.
- *Disruption:* Internet enabled sensors and devices are becoming part of the ICT ecosystem. These devices are increasingly being used to facilitate distributed denial of service (DDoS) attacks, in which malicious actors flood a target with service requests to overload the system in order to disrupt or to extort. Many of the devices in the near future will be wireless micro-devices embedded in infrastructure, with minimal security protection, so as the networks expand they will be more vulnerable to attack.

Opportunities

- *Efficiency:* intelligent distribution and use of resources through ICT, AI and complexity modelling will enhance the efficiency of systems, make better use of existing infrastructure and reduce the need for additional infrastructure.
- *Flexibility:* data mining and deep learning at an infrastructure level enable AI to predict supplies and demands and respond quickly to any variations. This is especially important as more renewable energy supplies become part of the supply mix or buildings become energy producers as well as consumers.
- *Transparency:* intelligent infrastructure, such as smart grids, involves two way flows of communication between buildings and the network. Users can monitor resource use and modify behaviour to reduce consumption or save money and suppliers can monitor usage and modify tariffs or incentives to better manage resource use.
- *High quality:* networks take the strain of peaks and troughs in demand of both consumer and supplier.
- *Resilience:* intelligent infrastructure can take the strain during extreme events.
- *Environmentally friendly:* intelligent energy infrastructure (electrical energy and heat) allows us to manage a wide variety of primary energy sources. If we want to reduce carbon emissions and increase the utilisation of renewable energy, then the infrastructure will enable us to meet these objectives.

Environmental infrastructure

Energy

Challenges

- *Building energy consumption*: as the number of buildings increases with population and economic growth, electrical energy demand will grow, which will cause high power system loading on existing infrastructure and result in overstressed equipment.
- *Thermal demand*: approximately 50% of a building's energy use (Ürge-Vorsatz, *et al*, 2015) is from thermal demand, such as for space heating, cooling and hot water provision. The majority is provided by fossil fuels such as coal, natural gas and oil. In developing countries of South East Asia, cooling demand at present is up to 70% of total thermal demand and consumption will increase significantly as cities expand. As people become wealthier, they will demand modern facilities such as air conditioning.
- *New consumers*: demand will increase not just due to the increase in the urban population, but because of technological advances in such areas as transportation (electric vehicles and urban public transport), data handling (telecommunication hubs, data centres and server buildings), and robotics (automation of tasks currently carried out by people).
- *Urban heat island effect*: the growth of cities and an increasing population density will cause ambient temperatures in cities to increase in comparison to the surrounding areas (the heat island effect). Even without factoring in increasing temperatures due to global warming, there will be increasing instances of heat waves, which can cause heat exhaustion and heat stroke, leading to an increase in illness and mortality in vulnerable sections of society. Building energy consumption will increase to counteract the heat island effect due to the demand for building air conditioning, which will result in overloading of the electrical network. Current practice is to bring on low efficiency, highly polluting stand-by plants and ration supplies (rolling power cuts, charges to discourage use, incentives to encourage use at off-peak times) at peak times or during heat waves.
- *Renewables*: Figure 4 shows the share of global demand met by renewables at present and by 2040 in the new policies and the 450 scenarios (IEA, 2016a). As renewable energy increases in capacity and share of global demand, the infrastructure will need to be able to manage the intermittent and fluctuating output.

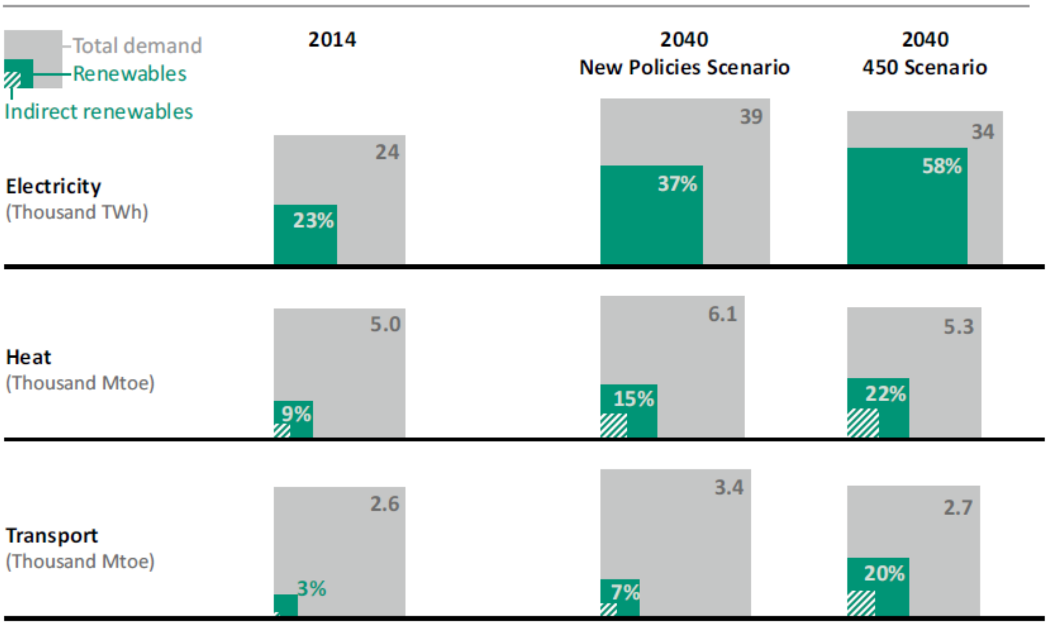


Figure 6.4. Share of global demand met by renewables in selected sectors in new policies and 450 scenarios (IEA, 2016a).

- *Micro-generation (<50kW)*: buildings will increasingly be electrical generators as well as users, though expansion of micro-generation systems such as solar photovoltaics, wind turbines, combined heat and power (CHP) and micro-CHP systems. The network will need to be able to manage the variable nature of supply and demand between individual buildings and the infrastructure.

Opportunities

- *Building consumption*: innovations in intelligent building technologies are reducing electrical energy consumption in traditional areas such as lighting and high performance glazing and facades, but most buildings consume more energy than predicted, therefore there are opportunities to reduce energy consumption further by improved prediction and control. Complexity modelling and deep learning are emerging technologies that involve data mining, analysis, forecasting and prediction using AI algorithms. The data mining will not be limited to the analysis of individual buildings, but will encompass the gathering of a wide variety of information from different parts of the infrastructure connecting the building, its occupants and its surroundings.
- *Thermal demand*: In 2008 heat losses of the EU27 energy system before end use were 39.3EJ, around 19EJ were from electricity generating power stations and so were not recoverable, but the remainder (29EJ) was considerably more than the demand of around 11 EJ (Andrews, *et al*, 2012). In large urban conurbations and cities, district heating and cooling (DHC) could play a major role in increasing energy efficiency, by using waste heat from electrical power generation plants and waste incinerators for thermal demand, utilising low grade heat sources that would otherwise be wasted (industrial processes), utilising renewable and low carbon heat (solar thermal, biomass, geothermal), reducing the need for electrically powered cold thermal demand (compression chillers) by using heat driven absorption chillers, heat pumps and free cooling (rivers, sea water, aquifers). DHC infrastructure usually includes means of thermal storage, and so peaks and troughs of demand from buildings can be managed within the DHC network. AI can be used in DHC networks to optimise the performance of individual buildings and the overall network.

- *New consumers*: Electric vehicles such as cars and buses will require additional electricity capacity, but could be used as short term electricity storage systems in buildings. Intelligent infrastructure requires more storage capacity to manage supply and demand and so electric vehicles could help to manage the system. Data centres are emerging as major electrical energy consumers and carbon dioxide emitters due to the need for cooling. Developments in low temperature DHC will enable the low grade heat generated from data centres to be used, whilst at the same time reducing electrical energy demand.
- *Urban heat island*: Intelligent buildings could play a role in tackling the problems, such as developing green roofs, facades and building envelopes that selectively absorb/reflect solar radiation to reduce the effect, but buildings themselves could not solve the problem. It will require the infrastructure of the city or district to be modified, so that there is a balance between highly absorptive structures such as buildings, roads and pavements and green spaces, heat refuges and shelters.
- *Renewables*: renewable energy systems requires intelligent infrastructure that can accept the intermittent and variable nature of the output and a robust and resilient network to manage the flows. As renewable energy generation grows from a small contribution to dominating the energy supplies, intelligent infrastructure will need to develop innovative energy storage systems. Energy storage could take the form of electrical (batteries) thermal (hot water or ice), mechanical (flywheels/compressed air), chemical (salt hydrates) or electro-chemical (batteries/ fuel cells).
- *Micro-generation*: Buildings with integrated renewable energy systems will increasingly be developed in the coming years, and there are many advantages to generating renewable electricity and heat at a building level. Solar and wind act on buildings whether we utilise the energy or not, so it makes sense to extract some of the energy if it is practically and economically feasible to do so. Buildings can reduce their utility bills, or can gain a revenue stream by selling any excess. Management of the fluctuating and variable supplies will be challenging to the electrical network, and so energy storage will need to be integrated into the electricity infrastructure.

Water

Challenges

- *Demand:* A large share of the water (up to 90%) withdrawn by households and services in high per capita use areas (developed countries such as the North America and Europe) is returned as wastewater, which requires treatment and energy consumption. The majority of water withdrawn in the municipal sector is for non-personal use, such as flushing toilets, washing dishes and clothes, watering lawns and washing cars (Cosgrove and Rijsberman, 2000).
- *Urbanisation:* Urbanisation is projected to grow from one-third urban in 1950 to two-thirds urban in 2050 (UN DESA, 2015). The water/energy infrastructure will need to be maintained and expanded to meet the growth in demand for clean water and the provision of sanitation.
- *Environment:* All uses of water cause some level of pollution, which needs to be treated before it can be reused. Less than 100% of pollutants are removed because of prohibitive costs, so some remain in the water or accumulate in the soil. In developing countries, the provision of sanitation is not keeping up with population growth, resulting in increases in pollution of water and the aquatic environment.
- *Health:* If water services do not keep up with demand in rapidly expanding urban areas, then this will lead to an increase in water-related diseases and deaths (3.4 million deaths due to waterborne diseases in 1998 (WHO, 1999)).

- *Unplanned development:* Rapid and unplanned urbanisation in developing countries has led to the expansion of slums or informal settlements (one third of all urban residents in developing countries live in informal settlements (UN DESA, 2015), and will continue to pose health risks and impede the life chances of people due to the lack of access to clean water and sanitation.
- *Conflict:* Transboundary river basins account for around 60% of all freshwater flow and supplies around 40% of the world's population (IEA, 2016b). Management and use from one location can affect downstream locations, thus creating potential tensions between states.

Opportunities

- *Energy efficiency:* Increases in the efficiency of energy production and power generation systems will reduce withdrawals and demand for water. This in turn will reduce the need for water treatment. CHP and waste heat recovery systems linked though DHC networks can also improve the efficiency of the power and heat supply infrastructure.
- *Waste-water recovery:* Energy recovery from wastewater could provide opportunities to improve the efficiency of the water treatment process.
- *Embodied energy:* There are opportunities to exploit the embodied energy in waste-water by generating electricity from biogas.

6.3 Future scenarios

Energy

Global economic growth is set to more than double over the next 20 years and energy demand and CO_2 emissions are set to increase alongside. Figure 3 (IEA, 2016a) shows the trends in three scenarios, current policies, new policies (taking account of broad policy commitments and plans that have been announced by countries) and 450 scenario policies (an energy pathway consistent with the goal of limiting the global increase in temperature to 2°C by limiting concentration of greenhouse gases in the atmosphere to around 450 parts per million of CO_2). In new policies scenarios, energy demand CO_2 emissions are still set to increase and in the 450 scenario, energy demand is projected to flatten out and CO_2 emissions are set to decrease.

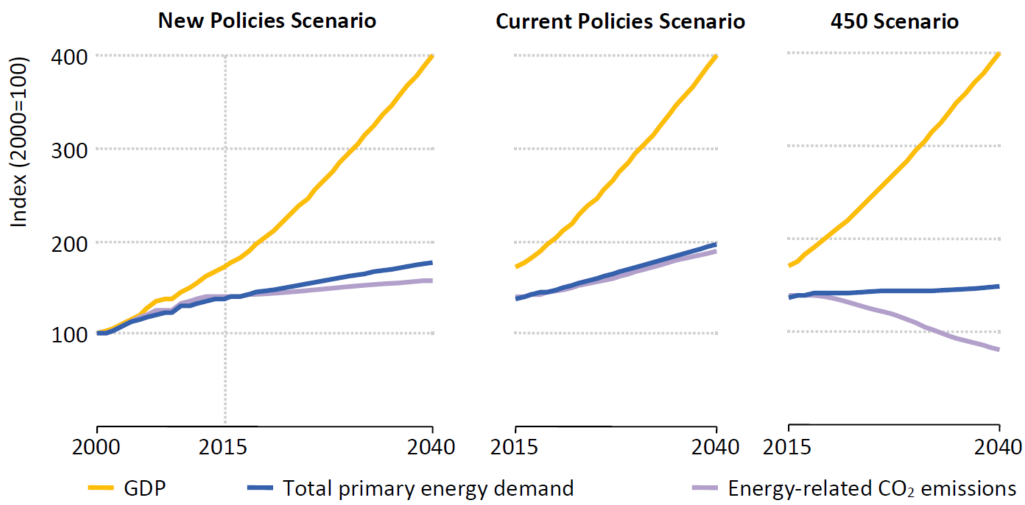


Figure 6.3. Global GDP, energy demand and CO_2 emissions trajectories by scenario (IEA, 2016a).

Buildings are responsible for over 40% of energy consumption and 33% of carbon dioxide emissions (IEA, 2016a). As over half of the population of the planet now live in cities (UN DESA, 2015), and cities become more densely populated, meeting the demand of a growing and wealthier population requires drastic action to mitigate and reduce the effect on the environment and resources and to better utilise renewable and low carbon resources.

Water

Water is an abundant resource, but only about 2.5% of it is freshwater. Of that, less than 1% is available for human use, as almost 70% is held in glaciers and ice, and roughly 30 % is deep underground or unsuitable for human consumption. Most of the supply is from surface water and groundwater sources, with global freshwater withdrawals increasing by around 1% per year since the 1980s. The withdrawal rate is outpacing the recharge rates by 1-2% per year globally, therefore groundwater sources are diminishing and becoming more vulnerable to seawater intrusion. Agriculture is the main cause of withdrawals and water consumption. The municipal sector accounts for 13% of withdrawals and 5% of consumption, the energy sector (power generation and primary energy production) accounts for 10% of withdrawals and 3% of consumption, whilst the industrial sector accounts for 12% of withdrawals and 8% of consumption. It is projected that withdrawals to meet municipal demand will increase 17% by 2040, withdrawals to meet industrial demand are projected to remain approximately the same (8-9%), and withdrawals in the energy sector are expected to rise by around 2% by 2040, but consumption is expected to rise by almost 60% (IEA, 2016b).

6.4 Development strategy

The development strategy for both intelligent buildings and the intelligent infrastructure that serves them should aim to integrate the social, the smart and the environmental aspects holistically. Concentrating on one aspect at the neglect of others may deliver some positive outcomes, but will not provide modern, efficient, cost effective, profitable, sustainable and pleasant environments in which people live and work.
Specific topics for consideration.

Well-being

Most buildings are designed to be occupied by human beings, but well-being is often low on the priority list, if considered at all. Well-being can be enhanced though the design of a space, and the consideration of human physiology and physiology, but if occupations are stressful or unfulfilling then well-being can be seriously undermined. There will always be occupations that can undermine well-being, and stressful or unfulfilling jobs will always be with us, but intelligent social infrastructure can create urban spaces that mitigate some of the negative effects and make work more productive.

Hard and soft infrastructure

A balance must be found between hard and soft infrastructure. We define hard infrastructure as that which consists of concrete, glass and steel buildings, roads, pavements, plazas, and soft infrastructure as that which consists of parks, gardens, wildlife corridors, green roofs, water features.
A concentration on hard infrastructure contributes to overheating of cities in summer, which leads to higher energy consumption, an increase in pollution and carbon emissions, and impacts on human health and mortality. From an environmental point of view, soft infrastructure provides shelters from heat and cool spots, it can reduce the overall heat island effect, it also absorbs carbon dioxide and releases oxygen and water vapour into the atmosphere. It is now widely recognised that people respond positively to a connection with nature, whether that is for leisure or work, so that health and well-being can be enhanced (assuming that work-life balance and satisfaction can be achieved), improving motivation and productivity, whilst reducing costs.
A balance between hard and soft infrastructure can be developed using many emerging techniques

such as constructal theory, fractal geometry, evolutionary algorithms, data mining and machine learning.

Distributed energy

Cities and megacities consume vast quantities of energy due to their high urban density, but this concentration of buildings and people presents opportunities for distributed energy systems due to economies of scale.

District heating and cooling networks (DHC)

Cities are increasingly turning to DHC to provide heating and cooling that is potentially more energy efficient, can reduce carbon dioxide emissions and enables more flexibility at a building level. DHC have traditionally been driven by combined heat and power (CHP) systems that are fuelled by fossil fuels, but renewable heat can be integrated as well as providing a variety of fairly simple energy storage methods (including hot water, steam, molten salt, phase change materials (PCMs)). Cooling to data centres and server farms, cloud computing factories is increasingly being sited in northern regions to take advantage of natural cooling from lakes and rivers.

DHC generate data which can be used to optimise delivery of heat as well as minimising energy consumption and maximising the use of renewable heat.

Renewable energy

It is important that renewable and low carbon energy systems are integrated into a city's buildings and infrastructure. Just placing solar panels or wind turbines on roofs may not help in providing energy to cities, so it is important that the siting and orientation of such systems are optimised. It may be impracticable to install a system on one particular building, because of layout, orientation or location, but be practicable on another building. A distributed network at an infrastructure level would maximise the production of renewable energy, whilst making the overall system more cost effective.

Water-energy

We are surrounded by water, but very little of it is available for human use. We need to be much more thoughtful about our use of water. Most of the water is for non-human consumption, but we extract it from aquafers or reservoirs (which mainly come from run-off), treat it to a standard suitable for human consumption and pump it to cities. Non-potable water can be recycled for use close to the customer. Economies of scale mean that cites should re-use most of the water consumed, reducing the need for fresh water and the energy required to process and deliver it.

Sustainable cities

Sustainable development is most commonly defined as that which "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Buildings and urban infrastructure are a major cause of unsustainable development, but one of the easiest to fix, whether it is modifying existing buildings and infrastructure or developing buildings and infrastructure that are closer to the definition of sustainable development. It is not "rocket science". It is not necessary to invent new materials, design new machines or develop new fuels to design sustainable spaces, although innovations can feed into the solutions and make a difference. It is a mainly a matter of creative design. Therefore, architects, engineers and urban designers play the most crucial role in developing intelligent buildings and infrastructure, an example of intelligent social infrastructure. If these important professions work together from concept to handover, then they will be more successful in achieving their goals, and be more sustainable, should this be one of their goals. If these professions work separately or development is linear (concept/structure/services/control/facilities management) then success is less likely.

Smart cities

The emergence of smart technologies such as robotics, AI, data mining and manipulation, and pervasive computing has great potential to improve the lives and prosperity of citizens but has many downsides, as described in the state-of-the- art review. A development strategy for intelligent buildings should embrace the emerging technologies, but mitigate the negative effects. Cities are great engines of economic development, but as employment patterns and occupation categories change, it is the responsibility of its governors to act in the interests of its citizens to ensure that they benefit from the opportunities. Each city or urban space will have different ways of balancing the benefits and costs of the development of smart technologies, but if only a small proportion of its citizens benefit from the changes then social unrest will result. Cities are places of growth, but also places of protest and revolution.

Megacities

There are over a twenty megacities with populations exceeding 10 million people, and most of them are in developing regions of the world. This report focusses on how intelligent buildings and its infrastructure can produce a better world for the people living and working in it, whether it is employment, health and well-being, sustainable development, or technologies that connect people and improve services. However out focus tends to fall on modern cities in the developed world that have a civic infrastructure that tends to reduce the inequalities that arise when there are few checks and balances. In developing regions, where civic society is less well established, informal settlements are common and tolerated. It is important that advances in buildings and infrastructure are applicable to developing countries and the outcomes can reduce the prevalence of slums, tackle poverty and improve the life chances of people living on the margins of society.

6.5 Research Contribution

The research community can contribute to the advancement of intelligent buildings and infrastructure by gaining a better understanding of the interface between social, smart and environmental infrastructure.

Research at the interface between social, smart and environmental infrastructure should aim to;

- Gain a better understanding of the relationship between changing work patterns and health, well-being and productivity with respect to buildings and infrastructure.
- Develop techniques investigating the relationship between hard and soft infrastructure on health, well-being and productivity.
- Understand the life-cycle costs of intelligent buildings and infrastructure, using a range of scenarios.
- Develop strategies for optimizing hard and soft infrastructure.
- Develop models and methods for integrating distributed energy infrastructure.
- Develop techniques for optimizing distributed energy infrastructure using techniques including data analytics, constructal theory, fractal and evolutionary algorithms.
- Develop systems and infrastructure that integrates water and energy systems.
- Develop working methods that encourage teamwork across disciplines.
- Develop systems that integrate smart technologies (big data, AI, IoT, robotics) between buildings and infrastructure.
- Provide solutions that are practical and affordable, so that they can be applied to developing regions.

6.6 Research Agenda

Researchers need to work across disciplines to develop new thinking, so that everyone benefits from advances in intelligent buildings and infrastructure. We will need contributions from the scientific community and from the humanities. If we are to create buildings that serve the people working and living in them then physiological, physiological and social aspects will need to be addressed as well as the scientific and technical.

The future direction of research in intelligent buildings and infrastructure should focus on:
Developing working methods that encourage team working between different disciplines from the concept stage. It should be recognised that non-technical disciplines are important to the development of intelligent buildings and infrastructure.
Ensuring that building owners and occupants benefit from development.
Ensuring that the wider community benefits from development.
Ensuring that advances in intelligent building and infrastructure is accessible and cost effective to developing regions.
Where possible, water and energy services development should be integrated.
Sustainability must be a high priority, but this must be balanced with the need of building occupants (health and well-being) and building owners (payback times, life cycle costs).
Smart technologies should be embraced, so that the benefits that they bring can be realised, but this must not be at the expense of personal liberty or privacy. Transparency is vitally important, so that data that is being accessed and manipulated is with the consent or knowledge of the individual or organisation.

References

Airaksinen, M, Porkka, J, (Eds) (2016), research roadmap report smart city vision, CIB Publication 407, Pub: CIB General Secretariat, The Netherlands, p. 60.
Andrews, D, Riekkola, A, K, Tzimas, E, Serpa, J, Carlsson, J, Pardo-Garcia, N, Papaioannou, I, (2012), Background report on EU-27 district heating and cooling potentials, barriers, best practice and measures of promotion, Joint Research Centre Report EU25289 EN, European Commission, Luxembourg, p. 215.
Cosgrove, W, J, Rijsberman, F, R, (2000), World Water Vision, Ch 2: The use of water today, Earthscan Publications Ltd, London, UK, pp.6-22.
El-Hawary, M, E, (2014), the smart grid: state-of-the-art and future trends, Electric Power Components and Systems, V42, (3-4), pp. 239-250.
Evans, D, (2011), The Internet of Things: how the next evolution of the internet is changing everything, White paper, CISCO Internet Business Solutions Group (IBSG), P.11.
Frey, C, B, Osborne, M, A, (2017), the future of employment: how susceptible are jobs to computerization? Technical forecasting and social change, V114, (Jan), pp. 254-280.
IEA, (2016a), World Energy Outlook 2016, Part B, Ch 10: special focus on renewable energy, International Energy Agency, Paris, France. pp. 395-443.
IEA, (2016b), World Energy Outlook 2016, Part A, Ch 9: water-energy nexus, International Energy Agency, Paris, France. pp. 347-394.
Klepeis, N, E, Nelson, W, C, Robinson, J, P, Tsang, A, M, Switzer, A, M, Bhar, J, V, Hern, S, G, Englemann, W, H, (2001), The national activity pattern survey (NHAPS): A resource for assessing the exposure to environmental pollutants, J of Exposure Analysis and Environmental Epidemiology, V11, (3), pp.231-252.
Lottrup, L, Grahn, P, Stigsdotter, U, K, (2013), workplace greenery and perceived level of stress: benefits of access to a green outdoor environment at the workplace, Landscape and Urban Planning, V110, (Feb), pp.5-11.
Nilon, C, H, Berkowitz, A, R, Hollweg, K, S, (2003) Ecosystem understanding is the key to understanding cities: Introduction, Springer International Publishing AG, New York, pp.1-13.
UN DESA, (2015), World population prospects, 2015 revision: key findings and advance tables,

working paper No. ESA/P/WP.241, Department of Economic and Social Affairs Population Division, United Nations, New York, 2015. P66.

Ürge-Vorsatz, D, Cabeza, L, F, Serrano, S, Barreneche, C, Petrichenko, K, (2015), heating and cooling energy trends and drivers in buildings, Renewable and Sustainable Energy Reviews, V41, (Jan), pp.85-98.

WCED, (1987), our common future. World Commission on Environment and Development, Oxford University Press, Oxford, UK, p. 300.

WHO, (1999), the world health report 1999: making a difference, World Health Organisation, Geneva, Switzerland, p. 136.

7. Sustainable urban transportation in intelligent cities

Xingxing Zhang

7.1 Air quality in underground built environment

Background and Description

Millions of people in metropolis benefit from the convenience of underground systems, which reduce the traffic congestion above the ground. However, during the recent large-scale proceeding of urbanization of developing countries, like China, the underground traffic has raised significant issues ever to the large-and-medium sized cities. One of the severe problems is indoor air quality (IAQ) in underground systems due to heavy use and overcrowding, unsustainable operation in public transportation and etc.

Most underground systems are designed as confined space where air pollutants are generated and diffused as well as enter from outside atmosphere. Hence, various types of air pollutants which bring threats to human's health are accumulated in underground systems. IAQ must be a matter of great concern because regular passages passengers and underground working staff spend considerable time in the underground system daily. Therefore, in order to ensure the passages passengers and underground working staff health, relative researches and implements are necessary for controlling the hazardous air pollutants in the underground system.

Recently, a few studies have been reported to monitor the IAQ and propose strategies to mitigate this issue. Inhalable particulate matter (PM) concentrations are typically much higher than those above ground according to some published studies, nonetheless, the substantial factors impacting the production and shape of PM are heterogeneous that rarely illustrated solitarily yet. The geographical areas, indicated in **Fig. 7.1**, discussed include Montreal (Boudia et al., 2006), New York (Ruzmyn et al., 2015), Los Angeles (Kam et al., 2011), Paris (Bachoual et al., 2007; Tokarek and Bernis et al., 2010), Mexico city (Hernandez-Castillo et al.,2014; Mugica et al., 2012; Gomez-Perales et al., 2004), Shanghai (Li et al., 2012; Huan et al., 2014), Beijing (Jing et al., 2012), Guangzhou (Chan et al., 2002), Xi'an (Gao et al., 2015), Suzhou (Cao et al., 2017), Tianjin (Wang et al., 2016), Taipei (Kam et al., 2011), Seoul (Son et al., 2012; Kim et al., 2008), Fukuoka (Chang-Jin et al., 2012), Tehran (Hosein et al., 2014), Puna (Delbari et al., 2016), Istanbul (Sahin et al., 2012), Bracelona (Moreno et al., 2014), Stockholm (Klara et al., 2012), Helsinki (Aarnio et al., 2005), Milan (Colombi et al., 2013), Rome (Perrino et al., 2015) London (Pakbin et al., 2010; Adams et al., 2001) and Birmingham (Harrison et al., 1997). The majority of this research was conducted via on-site testing of PM at different sites in the subway stations, i.e. the station hall, carriages etc., with corresponding analysis on the distribution and physicochemical properties of PM2.5 in each location in the subway station. For instance, Kam et (2012) measured the concentration of the particles in six different cities for eight years in eastern of America. Then they analyzed the correlation between death rates and the particles and they found that correlation between mortality and the PM2.5 was strong. Delbari et al (2017) reported that the mortality would increase 1.5% when the average concentration of the PM2.5 increases 10 $\mu g/m^3$, Pope C et al (2002) also got similar results. Moreover, some researchers have reported that the concentration of particles in the subway were much more than the outside environment and they were much more gene toxic which could cause more healthy problems to public (Kijnzli, Kaiser et al. 2000, Guo, Hu et al. 2014). Now there are many studies, which measured the particles in public transportation including the Metro, buses and so on (Adams, Nieuwenhuijsen et al. 2001, Cheng, Lin et al. 2008, Cheng and Yan 2011, Kam, Cheung et al. 2011, Cheng, Liu et al. 2012). In these studies, the factors influencing concentration and distribution of PM in subway stations include seasons, weather, time, traffic density, brake system, ventilation system, passenger density, depth, design, aboveground or underground, operating duration, location, piston effect, outdoor traffic (Park et al., 2008, Li et al., 2012, Cheng et al., 2008, Hernandez-Castillo CR et al., 2014, Moreno et al., 2014, Midander et al., 2012, Aarnio et al., 2005, Boudia et al., 2006). And the measured targets or components in subway stations were outdoor climate conditions, platforms, passenger carriages, driver compartments, station offices, rest areas, ticket offices, station precincts (Li et al., 2012, Hosein et al., 2014, Park et al., 2008, Huan et al., 2014, Ruzmyn et al.,2015, Kim et al., 2008, Cheng et al. 2008, Moreno et al., 2014, Midander et al., 2012, Kim et al., 2014, Aarni et al., 2005).

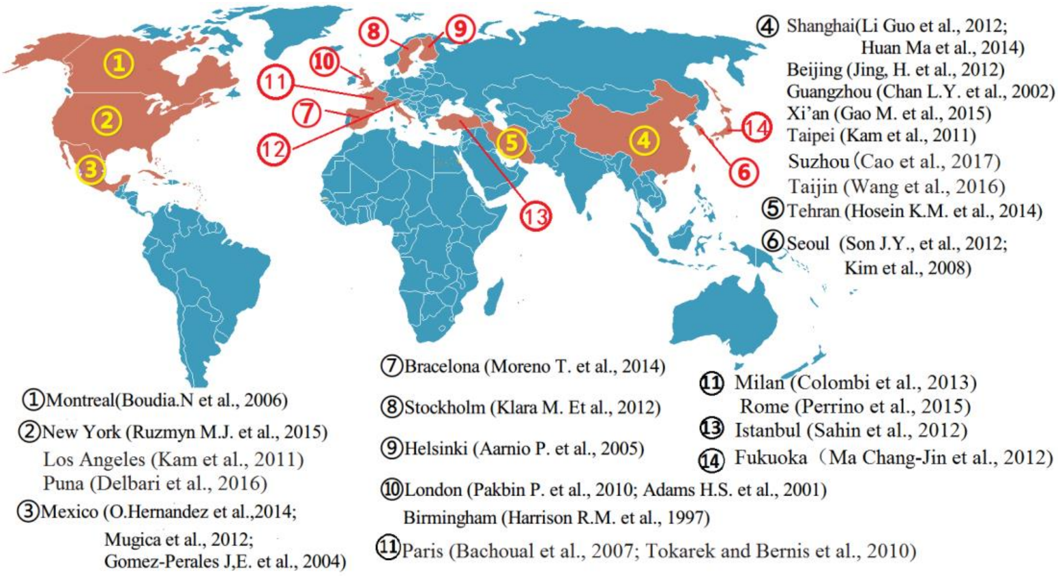


Figure 7.1 Geographical locations of research into PM2.5 in subways

According above studies, it is likely that the PM analytical results would be different if the studies were performed in another country or even in the same city, as the influencing factors and the measured targets/components may vary. To make an accurate assessment, it is necessary to carry out the local measurement and analysis. Besides the PM, coeval concentrations of CO_X, SO_X and NO_X are also significant sectors that should be investigated on underground train station platforms.

Sampling and observation are the primary method currently used for the physical and chemical characterization of IAQ in subways. The main physicochemical properties are: (1) the shape of pollutants in subways is complex and changeable; there are no stable or identical shapes identified; (2) current research focuses mainly on the elementary composition of pollutants; these chemical are not found as individual elements but as part of a compound. Current research demonstrates that the factors influencing the concentration and distribution of pollutants in subways included external, internal, human and operational factors. Pollutants sources in subways are usually divided into two categories: from the external outdoor environment and from the subway interior i.e. the perennial equipment, the ventilation systems and the train brake systems. The control strategy of pollutants relies on the features of the subway. In contrast to buildings over-ground, subway stations could be considered to be "semi open construction" and therefore obviously affected by the outdoor environment. IAQ in subway stations is dependent on the ventilation system with the control strategy provided by most of researchers being through prevention and control through ventilation. Although subway cabin air purifier (SCAP) has been used in subway carriages to reduce pollutants concentration, there is still a lack of definite methods for the control of platform and station hall ventilation systems.

Objectives

This road map aims to bring forward the urgency and necessary of mitigating the IAQ problem in underground built environment. It seeks to advance the understanding of indoor air pollutants and pertinent measures which save energy consumption, enhanced the IAQ level, and minimize the health risk in underground, by consolidating a large set of new peer-reviewed work that highlights the implement in the IAQ improvement and sustainable operation in underground system for future intelligent cities.

Future research potential topics may include, but are not limited to:

- IAQ in underground and suspended particulate matter
- IAQ in underground and source of air pollutants
- IAQ in underground and mortality risk reduction
- IAQ in underground and season dependent model
- IAQ in underground and thermal comfort
- IAQ in underground and energy saving
- IAQ in underground and ventilation system
- IAQ in underground and online monitoring
- IAQ in underground and numerical simulation
- IAQ in underground and sustainable operation

Focus of research and development

Systematic research method: sampling and observation is the primary method currently for the physical and chemical characterization of air quality in underground built environments. Due to the complexity of undergrounds, many people are sceptical about the accuracy of results and validity of data. Further research into the theory and methodology must be completed to improve data analysis.

Characterized measurement locations and long-term data collection: most of the existing studies focus only on a certain area or a certain underground so that the research results may have significant differences due to many varying factors. The characterized measurement locations in undergrounds need to be defined and made uniform, such as carriages, work areas, public areas (platform, station hall) and outdoor environment. Since the main analysis method used is sampling and observation, large accumulations of data will be required, which must be achieved through long-term measurements in underground built environments.

R&D in different locations and scenarios: The factors influencing the IAQ in undergrounds are different from locations and scenarios. It is very likely that the IAQ would be different if the studies are performed in another country or even in the same city. To make an accurate assessment, it is necessary to carry out the local measurement and build local database for analysis.

Control against energy saving: some researchers have argued from an energy-saving perspective that air only needs to be controlled within the carriage since passengers spend most time there. It has been suggested that underground air-conditioning and ventilation should be in mind from the very beginning of design up to final operation so as to control air distribution in undergrounds whilst consuming as little energy as possible.

Millions of people in metropolis benefit from the convenience of underground systems, which reduce the traffic congestion above the ground. However, during the recent large-scale proceeding of urbanization of developing countries, like China, the underground traffic has raised significant issues ever to the large-and-medium sized cities. One of the severe problems is indoor air quality (IAQ) in underground systems due to heavy use and overcrowding, unsustainable operation in public transportation and etc. Most underground systems are designed as confined space where air pollutants are generated and diffused as well as enter from outside atmosphere. Hence, various types of air pollutants which bring threats to human's health are accumulated in underground systems. IAQ must be a matter of great concern because regular passages passengers and underground working staff spend considerable time in the underground system daily. Therefore, in order to ensure the passages passengers and underground working staff health, relative researches and implements are necessary for controlling the hazardous air pollutants in the underground system. This road map aims to bring forward the urgency and the needs of mitigating the IAQ problem in underground built environment, especially at subway stations. It seeks to advance the understanding of indoor air pollutants and pertinent measures which save energy consumption, enhanced the IAQ level, and minimize the health risk in underground, by consolidating a large set of new peer-reviewed work that highlights the implement in the IAQ improvement and sustainable operation in underground system for future intelligent cities.

References

Aarnio, P, Yli-Tuomi, T, Kousa, A, Makela, T, Hirsikko, A, Hameri, K, Paisanen, M, Hillamo, R, Koskentalo, T, Jantunen, M. The concentrations and composition of and exposure to fine particles (PM2.5) in the Helsinki subway system. Atmospheric Environment, 2005, (39): 5059-5066

Adams, HS, Nieuwenhuijsen, MJ, Colvile, RN, McMullen, MAS, Khandelwal, P. Fine particle (PM2.5) personal exposure levels in transport microenvironments, London, UK. The Science of the Total Environment, 2001, (279): 29-44

Bachoual, R, Boczkowski, J, Goven, D, Amara, N, Tabet, L, On, D, Leçonmalas, V, Aubier, M, Lanone, S.
Biological effects of particles from the Paris subway system. Chem. Res. Toxicol, 2007, 20: 1426–1433.

Boudia N, et al. 2006. Manganese concentrations in the air of the Montreal (Canada) subway in relation to surface automobile traffic density. Sci Total Environ;366(1):143-7.

Cao, SJ, Kong, XR, Li, L, Zhang, W, Ye, ZP, Deng, Y. An investigation of the PM2.5 and NO2 concentrations and their human health impacts in the metro subway system of Suzhou, China. Environ Sci Process Impacts, 2017, 19, 666-675

Chan, LY, Lau, WL, Zou, SC, Cao, ZX, Lai, SC. Exposure level of carbon monoxide and respirable suspended particulate in public transportation modes while commuting in urban area of Guangzhou, China. Atmospheric Environment, 2002, 38(36): 5831-5840

Colombi, C, S, Angius, V, Gianelle, M, Lazzarini. Particulate matter concentrations, physical characteristics and elemental composition in the Milan underground transport system. Atmospheric Environment, 2013, (70): 166-178

Chan, LY, Lau, WL, Zou, SC, Cao, ZX, Lai, SC. Exposure level of carbon monoxice and respirable suspended particulate in public transportation modes while commuting in urban area of Guangzhou, China. Atmospheric Environment , 1992, (26): 2141-2148

Chang-Jin, Ma, Sigeo, Matuyama, Koichiro Sera, Shin-Do, Kim. Physicochemical properties of indoor particulate matter collected on subway platforms in Japan. Asian Journal of Atmospheric Environment, 2012, 6 (2): 73-82

Chueng, G, Zang, JB. Test and analysis of PM2.5 concentration in subway system. (in chinese). Refrigeration technology, 2014, (5): 13-16

Cheng, YH, Liu, ZS, Yan, JW. Comparisons of PM10, PM2.5, particle number, and CO2 levels inside metro trains traveling in underground tunnels and on elevated tracks. Aerosol Air Qual Res, 2012, (12): 879-891

Cheng, YH, Yi, LL, Chia, ChL. Levels of PM10 and PM2.5 in Taipei Rapid Transit System. Atmospheric Environment, 2008, (42): 7242-7249

Delbari1, AS, Hadavifar, M, Haghparast, H. Concentration and characterization of airborne particles in two subway systems of Islamic Republic of Iran and India. Journal of Air Pollution and Health, 2016, 1(2): 61-68

Gomez-Perales, JE, Covile, RN, Nieuwenhuijsen, MJ, Fernandez-Brem, Auntz, A, Gutierrez-Avedoy, VJ, Paramo-Figueroa, VH.
Commuters' exposure to PM2.5, CO, and benzene in public transport in the metropolitan area of Mexico City. Atmospheric Environment, 2004, (38): 1219-1229

Gao, ML, Cao, JJ, Edmund, Seto. A distributed network of low-cost continuous reading sensors to measure spatiotemporal variations of PM2.5 in Xi'an, China. Environmental Pollution, 2015, (199): 56-65

Harrison, RM, Deacon, AR, Jones, MR. Sources and processes affecting concentration of PM2.5 and PM10 particulate matter in Birmingham (U.K.). Atmospheric Environment, 1997, 24(31): 4103-411

Hernandez-Castillo CR, et al. Whole-brain connectivity analysis and classification of spinocerebellar ataxia type 7 by functional MRI. Cerebellum Ataxias. 2014.

Hosein, KM, Mahdi, CYJ, Gholam, HS. Concentration and characterization of airborne particles in Tehran’s subway system. Environment Science Pollution Research, 2014, (21): 7319-7328

Ma, H, Shen, HG, Liang, Zh, Zhang, LCh, and, Xia, Ch. Passengers’ Exposure to PM2.5, PM10, and CO2 in Typical Underground Subway Platforms in Shanghai. Proceedings of the 8th International Symposium on Heating, Ventilation and Air Conditioning, Lecture Notes in Electrical Engineering, 2014, (261): 237-245

Jing, H, Deng, FR, Wu, ShW, Guo, XB. Comparisons of personal exposure to PM2.5 and CO by different commuting modes in Beijing, China.. Science of the Total Environment, 2012, (425): 52-59

Kam, W, Cheung, K, Daher, N, Sioutas, C. Particulate matter (PM) concentrations in underground and ground-level rail systems of the Los Angeles Metro. Atmospheric Environment, 2011, (45): 1506-1516

Kam, W, Ning, Z, Shafer, MM, Schauer, JJ, Sioutas, C. Chemical characterization and redox potential of coarse and fine particulate matter (PM) in underground and ground-level rail systems of the Los Angeles Metro. Environ Sci Technol, 2011b, (45): 6769-6776

Kijnzli, N, Kaiser, R, Studnicka, M, et, al. Public health impact of outdoor traffic-related air pollution: a European assessment. Lancet, 2000, (365): 795-801

Kim, JB, Seyoung, Kim, Gwang-Jae, Lee, Gwi-Nam, Bae, Youngmin, Cho, Duckshin, Park, Duck-Hee, Lee, Soon-Bark, Kwon. Status of PM in Seoul metropolitan subway cabins and effectiveness of subway cabin air purifier (SCAP). Clean Techn Environ Policy, 2014, (16): 1193-1200

Kim, KY, Kim, YSh, Roh, Y, Lee, Ch, M, Kim, ChN. Spatial distribution of particulate matter(PM10 and PM2.5) in Seoul Metropolitan Subway stations. Journal of Hazardous Materials , 2008, (154): 440-443

Klara, Midander, Karine, Elihn, Anna, Wallén, Lyuba, Belova, Anna-Karin, Borg, Karlsson, Inger, Odnevall, Wallinder. Characterisation of nano- and micron-sized airborne and collected subway particles, a multi-analytical approach. Science of the Total Environment, 2012, (27): 390-400

Li, Guo, Yunjie, Hu, Qingqing, Hu, Jun, Lin, Chunlin, Li, Jianmin, Chen, Lina, Li, Hongbo, Fu. Characteristics and chemical compositions of particulate matter collected at the selected metro stations of Shanghai, China. Science of the Total Environment, 2014, (496): 443-452

Li, Jinjuan, Shao, Longyi, Yang, Shushen. The mechanism of the health effects of fine particulate matter. Environment Healthy, 2006, (2): 85-89

Moreno, T, Pérez, N, Reche, C, Martins, V, Miguel, E, de, Capdevila, M, Centelles, S, Minguillón, MC, Amato, F, Alastuey, A, Querol, X, Gibbons, W. Subway platform air quality: Assessing the influences of tunnel ventilation, train piston effect and station design. Atmospheric Environment, 2014, (92): 461-468

Mugica-Alvarez, V, Figueroa-Lara, J, Romero-Romo, M, Sepulveda-Sanchez, J, Lopez-Moreno, T. Concentrations and properties of airborne particles in the Mexico City subway system. Atmospheric Environment, 2012, (49): 284-293

Pakbin, P, Hudda, N, et, al. Spatial and temporal variability of coarse (PM10-2.5) particulate matter concentrations in the Los Angeles area. Aerosol Science and Technology, 2010, 7(44): 514-525

Park, Dong-Uk, Kwon-Chul, Ha. Characteristics of PM10, PM2.5, CO2 and CO monitored in interiors and platforms of subway train in Seoul, Korea. Environment International, 2008, (34): 629-634

Perrino, C, Marcovecchio, F, Tofful, L, Canepari, S. Particulate matter concentration and chemical composition in the metro system of Rome, Italy. Environmental Science & Pollution Research, 2015, 22 (12): 1-11

Pope, CA, Burnett, RT, Thun, MJ, Calle, EE, Krewski, D, Ito, K, Thurston, GD. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. JAMA, 2002, 9(287): 1132-1141

Ruzmyn, MJ, Vilcassim, George, D, Thurston, Richard, E, Peltier, and, Terry, Gordon. 2015. Black Carbon and Particulate Matter (PM2.5) Concentrations in New York City's Subway Stations. Environ. Sci.Technol., (48): 14738-14745

Şahin, UA, Onat, B, Stakeeva, B, Ceran, T, Karim, P. PM10 concentrations and the size distribution of Cu and Fe-containing particles in Istanbul's subway system. Transportation Research Part D Transport & Environment, 2012, 17(1): 48-53

Son, JY, Lee, JT, Kim, KH, Jung, K, Bell, ML. Characterization of fine particulatematter and associations between particulate chemical constituents and mortality in Seoul, Korea. Environ Health Perspect, 2012, (120): 872-874

Tokarek, S, Bernis, A. An exemple of particle concentration reduction in parisian subway stations by electrostatic precipitation. Environmental Technology, 2006, 27(11): 1279-1287

Wang, BQ, Liu, JF, Ren, ZH, Chen, RH. Concentrations, properties, and health risk of PM2.5 in the Tianjin City subway system. Environ Sci Pollut Res, 2016, (23): 22647-22657

8. Keeping Abreast with Technology

Eva D'Souza

In order to get the most out of the technology you have and to compete in the business world one has to keep abreast of emerging new technology. You deal with the technology for your personal use, at home, at work and wherever you go to connect with people and places and to deliver the work tasks. Technology is changing rapidly and to keep pace with it is not an easy task.

Having a technology awareness strategy should ease the pressure in keeping up to date with the technology. Some of the following factors should help in developing the strategy:

- List your requirements: Defining and developing specification what you want to deliver is very important.
- Define the period: Once you specify the project, defining the life span of various elements is essential
- Available resources: Engaging right resources and making sure the technology fit for purpose is the foremost
- Resilience: Any technology you use make sure it is robust and will sustain for the whole life cycle of the project
- Infrastructure: Choosing the right infrastructure to adopt technical changes, operating and maintaining and recycling techniques to meet the financial targets.

Looking forward:

We are losing the track of technology and depend more on intelligent systems and loosing human interaction. The same intelligent pace is not available when something goes wrong.

- Intelligent approach to meet the system requirements throughout the project cycle
- More reliable products
- More technical resources
- More intelligent practice in trouble shooting
- More cost effective systems

9. Digital Futures

Peter McDermott

9.1 Conceptual Framework

The impact of digital technology and artificial intelligence on business, automation and communications is transforming the world in many ways. The digital transformation is as significant as the impact of new technology in the agricultural and industrial revolutions.

In the built environment digital technology continues to have a transformative impact. The requirements and forms of many types of building, including shops, factories, offices and homes, are all changing rapidly with the digital revolution. No one is sure where what the destination will look like. Digital village halls? Smart offices? Pop up shopfront showrooms for digital retailers? Social hubs? Living pods? Virtual homes? All established building paradigms are being explored amid a new digital and globalised world. The impacts of climate change and popular unrest caused by inequality and rapid change in economic distribution reflect a more uncertain future.

The increasing prevalence of digital technology in every facet of modern life has included a significant impact on buildings. In fact, some would argue that the term "intelligent building" itself reflects an attempt to define how this innovatory and ubiquitous technology has transformed buildings and construction in the last thirty years.

From early attempts to automate control of buildings using large mainframe digital computers, to the current prevalence of distributed digital controls (DDC) in commercial and now increasingly in domestic buildings, to the redesign of the buildings themselves to reflect the organisational and increased cooling needs of information and communications technology (ICT), these changes have been immense.
Moore's law states that computer power doubles in power every 2 years and even thought this pace of change is set to slow, the new leaps forward in the field of Artificial Intelligence (AI) will soon impact design, construction and operation of digital buildings.

9.2 State of the Art

Most buildings currently use DDC to control their mechanical, electrical and public health (MEP) services. In a typical modern building, small digital computers typically called controllers (DDC), are distributed throughout the building. They monitor and control the local equipment in order to achieve the internal conditions and energy performance required by the occupants and legislation. The digital software applications used in these controllers are normally based on traditional sequential Boolean logic and three term control loops. Fuzzy logic and machine learning programmes are very rare.
In larger buildings, these discrete controllers are networked together with a personal computer or server /client computer system. This provides a human supervisory arrangement usually implemented by a real time graphical user interface. This networked system is called a Building Automation and Control System (BACS) or Building Management System (BMS), sometimes a Building Energy Management System (BEMS). Where the control of the MEP is integrated with other digital systems in the building such as CCTV, access control, fire alarm systems etc., the system is often called an integrated Building Management System (iBMS).

9.3 Future Scenarios

Several potential development trajectories for digital control of buildings are apparent. Commercial market pressure, user preference and security concerns will determine which approach prevails or dominates in the various applications.

Increasing use of cloud computing, where the digital software is hosted in remote data centres, offers the possibility of building automation as a remote service. Buildings would consist of MEP equipment with appropriate imbedded networked sensors and actuators. The digital intelligence will be provided and hosted offsite and delivered via the internet by specialist providers. These providers could also add value by use of “big data” analytics using machine learning and artificial intelligence (AI) to optimise the performance of building services. This scenario would offer the suppliers the benefits of a service type business model and the ongoing revenues associated with it. For the building owners and users there is the promise of setting business orientated KPIs for the specialist providers while giving them the freedom to focus on their core business. Whether this constitutes a virtual Intelligent building or rather a dumber building that is merely a component of a larger “Intelligent Organisation” is a debatable point. Opening up the building control devices and networks to the internet offers a huge target and opportunity for malicious fun for hackers, criminal gangs and state cyber warfare agencies. Cyber security becomes paramount in preventing a possible panacea for building performance become a Trojan horse for malevolent action by third parties currently unable to gain access to the buildings and people and organisation that inhabit them due to traditional and well understood physical security measures.

Another development trajectory for digital control could be the increasing use of packaged MEP equipment supplied with their own on-board DDC. The software could be optimised by the manufacturers to the specific applications for the functionality of that packaged equipment. The data from the packaged digital controls is then merely agglomerated via a standards based open protocol network to an integrated user interface. This would create a secure integrated building management system (iBMS) for the building. In this scenario, the building still retains the digital intelligence and therefore it is, in itself, an Intelligent Building and can operate as such without the connection to the wider internet and cloud based services   Individual equipment suppliers will monitor and their own specific applications and data can be gathered locally and exported for external data analysis as required without the security risks of permanent online transparency.

These technology scenarios are a subset of much bigger those societal changes driven by increasing globalisation, urbanisation, growing wealth in-equality, aging populations, and climate change. The biggest impacts of digital transformation will be the increasing automation of human work, the subsequent redundancy facing many tax paying workers but also possibly prefacing super-abundant production and expansion of leisure time. This will force a paradigm shift in how society organises itself and distributes the fruits of digital production throughout the human population. The big question will be that faced only by the very wealthy in the past: What will we do with our time? And in our field the smaller one “How will this affect our buildings?”

9.4 Development Strategy

Large internet giants like Google and Amazon are following the offsite intelligence scenario as this plays to their strengths in data centre provision and big data analytics.
The traditional suppliers of BMS and process automation are developing ever more sophisticated and cost effective products to support DDC or “edge computing” where the digital intelligence is distributed locally near point of use and retained within the building

9.5 Research Contribution

Academic Research could contribute by developing the basic knowledge of digital controls theory and application within buildings. Optimisation involves meeting sometimes competing criteria of occupant comfort, energy use, carbon emissions, and capital cost. Metrics that quantify these parameters and assist the trade-offs optimisation requires can help with decision making.

9.6 Research Agenda

Future academic research could contribute by examining the relative costs of the differing approached to providing digital automation and control in different applications, markets and scale of buildings. Research in the better application of data analytics, machine learning and AI as applied to building performance and optimisation could also be beneficial.

For the bigger digital society picture more research in the market and ownership models of technology companies and the impact of un-equal income distribution and increase leisure time on human health and wellbeing would help provide evidence for the ongoing political deliberations on future economic and social policy.

The impact of digital technology and artificial intelligence on business, automation and communications is transforming the world in many ways. This digital transformation is as significant and disruptive as the impact of new technology was in the previous agricultural and industrial revolutions.

In the built environment digital technology continues to have a transformative impact. In fact, some would argue that the term “intelligent building” itself reflects an attempt to define how this innovatory and ubiquitous technology has transformed buildings and construction in the last thirty years.

From early attempts to automate control of buildings using central mainframe digital computers, to the current prevalence of distributed digital controls (DDC) in commercial and increasingly in domestic buildings, from mandatory BIM to the redesign of the buildings themselves to reflect the needs of ubiquitous information and communications technology (ICT), these changes have been transformative.

Differing trends in digital control of buildings are apparent. Commercial market pressure, user preference and security concerns will determine which of these approaches prevails or dominates in the various applications.

Increasing use of cloud computing, where the digital software is hosted in remote data centres, offers the possibility of building automation as a remote service.

The traditional suppliers of BMS and process automation are developing ever more sophisticated and cost-effective products to support DDC or “edge computing” where the digital intelligence is implemented locally.

Which strategy eventually succeeds will be determined by the developers and users of the built environment.

10. Upskilling for technology enhanced collaborative working

Tong Yang, Rosangela Tenorio

Building information modelling (BIM) gets people and information working together effectively and efficiently through a set of interacting policies, processes and technologies (RICS 2014). BIM implementation has been changing the dynamics & behaviour of the design-construction supply chain, unlocking new, more efficient & collaborative ways of working. Meanwhile, this digital platform enables forensic tracking of high-quality information to support business outcomes through true collaborative effort amongst all stakeholders in the AEC industry (Holzer 2016; Strong & Burrows 2017).

10.1 nD capacity of BIM

Multi-dimensional implementations of BIM enable the integration of knowledge management systems and empower handling and sharing of digital information during the building's lifecycle (B1M 2015). Inclusion of accumulated information to building's operation phase through nBIM enables better decision making on design choices for optimal economic, environmental and social sustainability.

Figure 10.1 Illustration of 6D BIM (B1M 2015)

• 3D: The shared information model in a Common Data Environment (CDE). 3D information model includes graphical digital prototype of a physical building embedded with non-graphical information of actual building elements and systems for design analysis, visualization, optimization, and lastly, project data handover to a client at completion.

• 4D: (3D + time) Construction planning and scheduling visualisations. Project scheduling allows project team to map timings onto activities, simulate planned work is safely, logically and efficiently sequenced, ensure proper logistics, space utilisation in the construction phases of the project.

• 5D: (4D + cost) Cost estimation. The model uses intelligent content objects, various participants (architects, designers, contractors and owners) can use the model for real-time cost planning and trade verification. Real BIM objects from manufacturers will make cost calculation more accurate.

• 6D: (5D + operation and maintenance) Project lifecycle information. Owners/Facility managers can use the model or export BIM objects property information to existing FM software to operate and maintain the building with an integrated view of a built-asset throughout its life cycle, including constructability, sustainability and future-proofing factors.

10.2 Creative play and collaborative learning

Digital technologies enabled BIM collaborative processes to significantly improve the efficiency of design, construction and operation, and provide a platform for continuous upskilling for all (Klaschka 2014; Sanchez et al. 2016). Since the invention of LEGO bricks 60 years ago, it is still a legendary toy embracing the principles of systematic creativity into educational play. One of the new comers, ‘littleBits’, a set of interchangeable electronics modular snapping blocks introduced programming through simple and fun opportunities for creative design in various cartoon/drama themes (Bdeir 2012). Meanwhile, playful and community engagement learning activities were designed to create a successful collaborative environment- The Plug in units, that encourage teamworking and social learning to think, create, operate and maintain buildings and reuse it sustainably, productively and responsibly (Tenorio et al. 2018).

New generations of AEC students are very familiar with virtual gaming settings and generally motivated in the teamwork approach assisted by BIM-enabled visualization and information sharing (Sinclair 2006). Collaborative working is required to break the tradition of working in silos and sub-optimal work sequences, so the learning and training programmes would be benefited through multi-disciplinary cross-faculty curriculum planning and management (Jin et al. 2017) as current changes happening in the industry is depicted in Fig. 10.2 (Bernstein 2015).

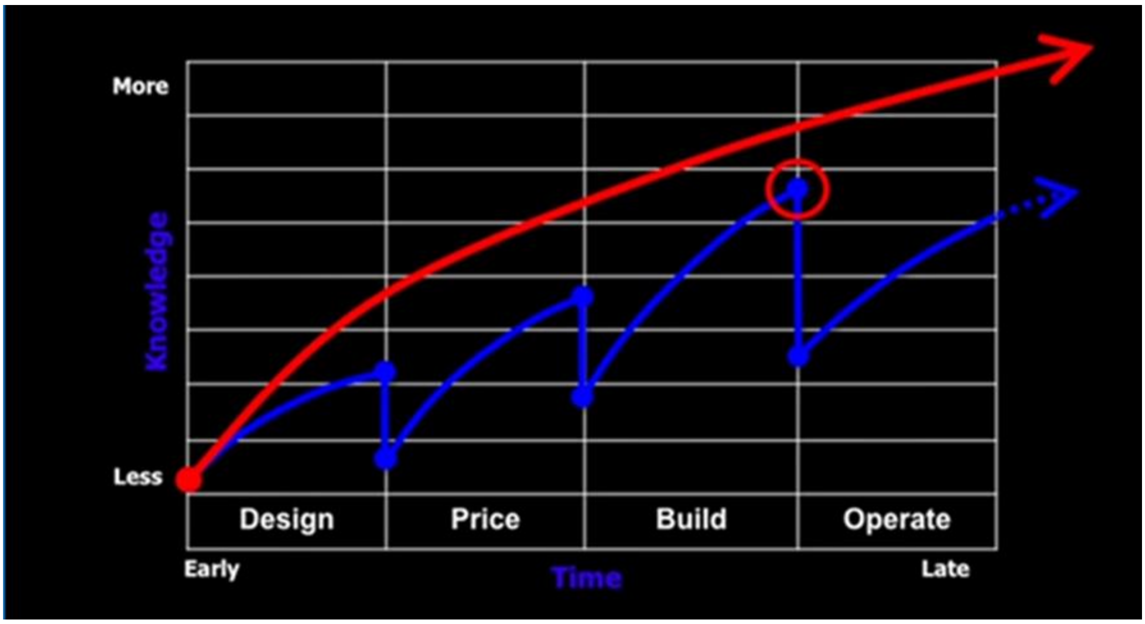


Figure 10.2. Collaborative information and knowledge management through a building’s lifecycle (Bernstein 2015)

10.3 Upskilling and managing changes

As the PESTLE factors (Political, Economic, Socio-cultural, Technological, Legal and Environmental) that influence all decision-making will be constantly shifting, BIM technology and processes provide a dynamic integrated learning platform/facility of sharing best practices and new skillsets (Fig10.3) for AEC workforce (Succar 2009).

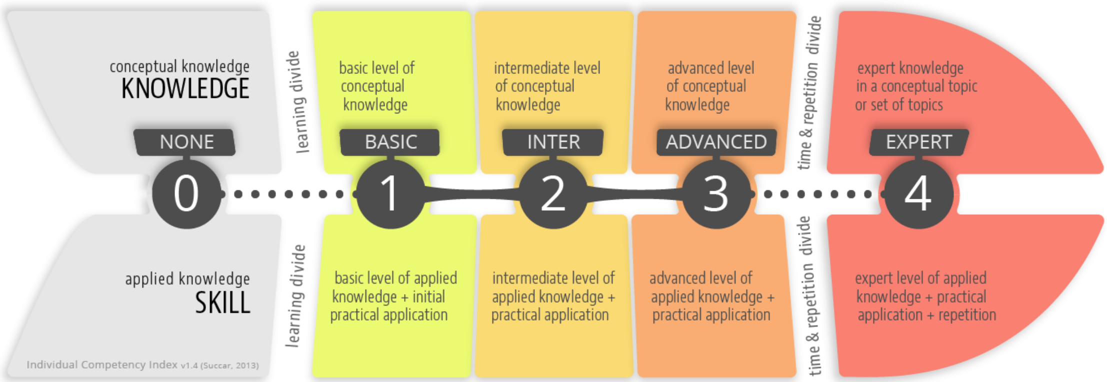


Figure 10.3. Individual BIM Competency Index (http://www.bimframework.info/competency/)

International standard ISO19650 supports the alignment of BIM standards to get a global industry working in a consistent and intelligent way. BIM skills learning and development must adapt to variations of PESTLE in a rapidly evolving industry. Effective change management with inclusive and open workflow of BIM will anticipate the impacts of emerging disruptive technologies, ever-more profound integration between information sources through all phases of projects, and continuously industry wide digital transformation with future-proof skilled workforce.

While universities are facing constant competition to attract students and keeping up pace with technology changes, the timely tasks for maintenance and renovation of ageing infrastructure with funding constraints could be the most suitable onsite learning opportunities and challenges for students. AEC students as the ambassadors of student communities could participate in key stakeholder groups (project sponsor, end user and project instigator) engagement meetings, are actively included in the communication process of planning and making technical, design and management decisions.

In addition to sound digital technology skills, students also need to acquire essential soft skills of effective cross-disciplinary collaborative working (Llewellyn 2015). Through project-based experiential learning on BIM implementation from the perspective of the lifecycle of a built asset, students can communicate with peers, academics, the supply chain, clients, customers and local government, and delve into best practices in the real-world. Decades of practical lessons learnt could be categorized and condensed into benchmark case studies through closer academic-industry collaboration. By producing virtual projects with real client brief for group learning, students would be encouraged to create ideas, make mistakes through learning-by-doing, and deliver in line with clear industry requirements and expectations to bridge the performance gap (iStructE 2017).

Students and staff with their mobiles and IoT devices could be a part of high resolution active human sensor network for intelligent and sustainable university estate operation. Big data analytics communicated through AI assistant could attract students to experience the first hand human-building interaction and occupant behaviour impact on live building performance dashboard (fig. 10.4). Through informed decision making on which data needs to be tracked over time for obtaining insight on building performance, students are trained to filter out noise and junks in the big data cloud and develop their critical thinking skills.

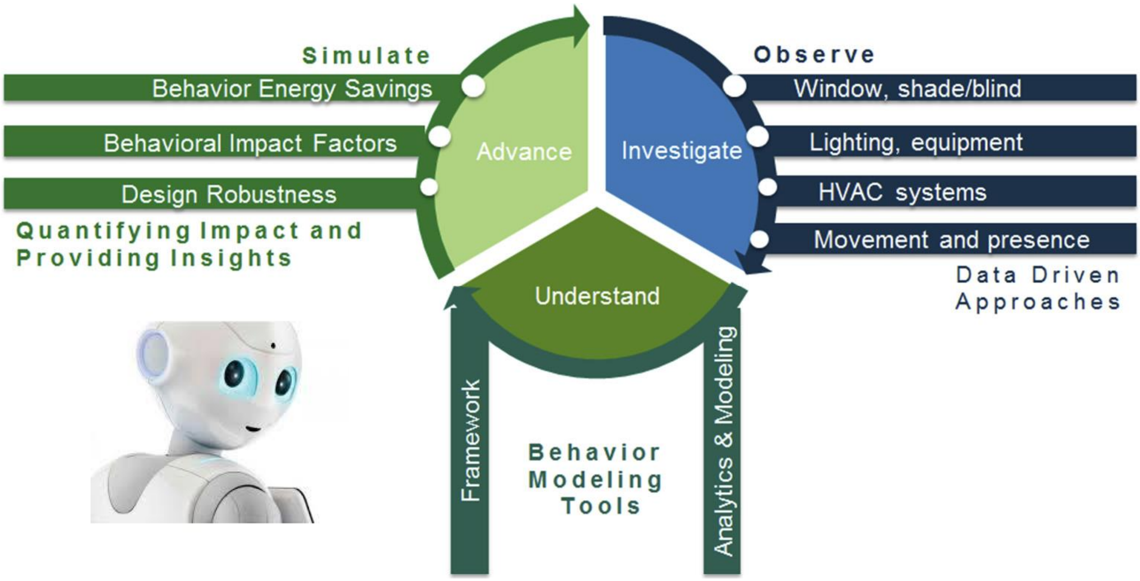


Figure 10.4. The human–building interactive energy behaviour loop (Hong et al., 2016)

10.4 Open source intelligent buildings and social infrastructure for the future

In our digital age, the open building concept (Kendall 2006) evolved and transformed with latest smart technology advances, AI enhanced design automation, offsite construction, etc. Futuristic sustainable intelligent buildings and cities could be realized by nurturing crowd based open source design and collective social infrastructure creation to improve the quality of life and the well-being of citizens (Sinclair 2006, Ingels 2016).

References

B1M (2015) What is 6D BIM? | The B1M, https://www.youtube.com/watch?v=N2ecyS7Odww (access 18Feb2018).

Bernstein P. (2015) The future of making buildings, Phil Bernstein at TEDxYale, https://www.youtube.com/watch?v=Kg0gbG1DAkk (accessed 10Feb2018).

Bdeir A. (2012) Building blocks that blink, beep and teach, Ayah Bdeir at TED2012, https://www.ted.com/talks/ayah_bdeir_building_blocks_that_blink_beep_and_teach and https://littlebits.cc/ (accessed 18Feb2018).

Ingels, B. (2016) Social Infrastructure, Bjarke Ingels at TEDxEast, https://www.youtube.com/watch?v=8PItGf69eaw (accessed 18Feb2018).

iStructE (2017) The built environment and the future of academic skills in higher education, Annual Academics' conference 2017, The Institution of Structural Engineers. 14 September 2017, London. https://www.istructe.org/academicsconference.

Kendall, S (2006) Open Building Concepts, CIB W104 Open Building Implementation, http://open-building.org/ob/concepts.html (accessed 18Feb2018).

Hong, T., Lange-Taylor, S. C., D'Oca, S., Yan, D., Corgnati, S. P. (2016) Advances in research and applications of energy-related occupant behavior in buildings, Energy and Buildings 116 pp694-702.

Llewellyn, T. (2015) Performance Coaching for Complex Projects: Influencing Behaviour and Enabling Change (Advances in Project Management), London and New York: Routledge.

RICS (2014) What is BIM? Royal Institution of Chartered Surveyors , http://www.rics.org/uk/knowledge/glossary/bim-intro/ (access 18Feb2018).

Succar, B. (2009). Building information modelling framework: a research and delivery foundation for industry stakeholders. Automation in Construction, 18(3), 357-375.

Tenorio, R. Yang, T., Oro, B. (2018) Gansu Studio: 'Plug-in' school unit for rural China, Asia & America Latina Journal, (Forthcoming Issue No.5/2018) www.asiaamericalatina.org

Sinclair, C. (2006) My wish: A call for open-source architecture, Cameron Sinclair at TED2006, https://www.ted.com/talks/cameron_sinclair_on_open_source_architecture (accessed 18Feb2018).

11. Wellbeing homes

Pete Halsall

Wellbeing homes are not an entirely new a concept; although for the last 50 years or so this idea has been more about the avoidance of ill health, rather than the augmentation of health. Clearly the focus of wellbeing homes now needs to return to how quality and longevity of life can be enhanced and extended, sustainably, so that people can live longer, happier and more fulfilled lives, with the wellbeing home as a key instrument for this. Frank Lloyd Wright made big promises, or at least big assumptions, for how his homes could impact on the quality of lives of their residents: " *People who live in these advanced houses must have a greater feeling for life, and be more themselves. It can be very liberating to see so many elements of nature.*" Those designing and developing the wellbeing home must take on this level of confidence and ambition, applying it to a contemporary setting. We are now in a period of quite extraordinary and unprecedented change and disruption - with the likelihood in the very near future of autonomous cars, digital lives, genetically modified babies, extraordinary technology - but what will all of this mean to how, and where we live, and to the quality of our lives ? At the same time as we race towards potentially exponential technological development, we are becoming increasing at odds with both the natural environment, but also potentially with our own nature. Surely a wellbeing home is one that, fundamentally, seeks to reconcile these increasingly dramatic and opposing forces so that we really need to live in much more natural and naturalistic environments, being in touch with and at ease with nature and our own nature, whilst enjoying the fruits of technology and harnessing hyper change to enhance wellbeing.

Ironically, the first thing that we have to do then is to get people as much out of their homes, as into them. Estimates vary, but it seems that in the West we now spend up to 90% of our time indoors; with the unsurprisingly attendant health issues - both psychological and physiological ensuing; social isolation, insufficient exercise, obesity, increasing dislocation from both nature, and therefore the corollary of that, an increasing dislocation from our own nature. So, with no small amount of creative tension, the essence of a wellbeing home must be one which we are both happy to be in, and at the same time, one which we are happy to not be in. The wellbeing home must be conceived as one which is as much outdoors as indoors, a lifestyle if you wish that has both the hardware of bricks and mortar, but also the software of increasingly complex and imaginative lifestyle choices.

In conceiving of the wellbeing home in a much more flexible way, then we need to think in terms of living in the city, and only, in part, in our homes. This indeed reflects how many Asian cities now are; In Seoul in South Korea, birthday parties are held in public parks, not lounges, rooms to play video games are rented with friends and not always now played in bedrooms, studying is done in generously sized coffer bar lounges or bookshops; indeed home is the last place that you go to after work, rather than the first place. So that the effect of all of this is that a wellbeing home makes no sense if we don't at the same time have the wellbeing city. Increasingly we should think of the city as where we live and the home as just one part of an increasingly complex patchwork of places, services and new ideas yet to be invented. We must then seek and strive equally for both the wellbeing home as well as the wellbeing city; the whole to be natural, vibrant, interesting, challenging, sociable, productive, full of multi-sensory experience, beautiful - and safe, both physically and also digitally, free of crime and cybercrime. Maybe we should think more about the nuclear family model, which is now sub-optimising how we live - perhaps it is now the ultimate barrier to a more collaborative and sharing based society where we must now with scarce optimise housing, cities and economics.

Focusing on the wellbeing home as a necessary subset of the necessarily wellbeing based city, we can see that the environmental aspects, both inside and out, are fundamental. We already know that our definition of what is functional needs serious re-thinking, and has largely been framed in the last 150 years around a startling ignorance of our own nature; so that a beautiful and engaging environment is not something which is nebulas or destroying of efficiency and utility, but rather something which enhances and optimises our psychological and physiological functioning - thus increasing utility and efficiency; the ultimate, 'value added' experience if you like, but played out in the everyday with the objective to enhance and extend both quality and longevity of life.

The state of the art for the wellbeing home has to start with high quality architecture, itself, arguably, the highest of all art because it can contain and contextualise all other art, and indeed science and technology; this must be the framework and concept around which everything else functions. Indeed, it was Frank Lloyd Wright who also said "*I believe that a house is more of a home by being a work of art.*" Some may say that this is an impossible dream - but the reality of modern manufacturing and consumerism is that pretty much everything becomes economically available to the majority, not just the minority of the population, in due course. We have then to start with economic and development models which free the market and the forces of innovation to deliver what everybody wants - a beautiful, wellbeing home, in a beautiful, wellbeing city, at prices that we can all afford. 3D printing and other advanced manufacturing techniques are making the decorative, the beautiful, the fractal - very readily available, and so there are increasingly no excuses for a lack of beauty.

From a technological stand point, we are now at a point we were are no longer constrained, certainly in the same way that we were in the past, by what technology is available - we can co-create, curate and commission new technologies to serve a plethora of lifestyle and wellbeing needs around the home. We must mine the huge amount of industrial and academic research to find new scientific understandings and to create new technological paradigms and specific solutions. The increasing blurring of what is home, what is housing technology, and what is 'us', rapidly reframes and extends what is possible. Fitbits which measure our skin temperature can be used to control heating systems - our outward breath can be monitored to set and vary ventilation controls - in each case room by room. Why not? Remember, the limit of technology, certainly in its conceptualization, has always been the limit of our imagination.

To accomplish all of this we must as part of creating the wellbeing home and the wellbeing city take back our democracy and increasingly advocate strongly and determinedly for change at the city level; for genuine and meaningful citizen participation in city governance. Citizens know better than the vast majority of designers now, and that is what is beauty is. If we believe that democracy is worth it, and that it counts, then we should not bat an eye lid. The wellbeing home and the wellbeing city need to be thought of as key aspects of a sustainable, egalitarian and truly democratic future; our first job then is to think, to design, to realise phenomena and new concepts at the socio-economic, and also at the pscyho-political levels, so that we can create the context in which the wellbeing home can become ubiquitous, by being affordable. In other words if we are to have the wellbeing home and the wellbeing city then we must first create the political and economic context in which this can happen.

12 Bioelectromagnetic Design

Isaac Jamieson

12.1 Conceptual framework:

What are we talking about? Game-changing interdisciplinary design/disruptive innovation that blends cutting edge biological research with technological innovation and international best practice to create new design paradigms for biologically friendly buildings, technologies and environments.

Technological innovation

An essential component aiding advancement in the new ‘Bioelectromagnetic Age’ is the creation of more bioelectromagnetically friendly intelligent and responsive buildings and technologies.

The need for detailed research into how to biologically optimise electromagnetic exposures in the built environment is long overdue, with rapid progress, development and deployment of effective (often low cost) technologies and techniques appearing possible in many areas.
This ground breaking initiative is also set to help the building industry better tap into the global Wellness Market, a trillion dollar industry that is already three times larger than the worldwide pharmaceutical industry. It represents disruptive innovation at its very best.

Enhancing health and well-being

We are presently experiencing exponential growth in environmental exposures to manmade electromagnetic phenomena. Often little thought is given to their potential positive or negative biological effects, a shortfall that can be actively addressed.

It is very important for us to investigate how healthier “next generation” bioelectromagnetic environments and technologies can be created.

12.2 State of the Art

What are the issues and where are we today?

Numerous studies demonstrate that electromagnetic phenomena can be biologically active. Knowledge already exists on how we can create healthier environments and this can be readily built upon.

Bioelectromagnetic health matters

The World Health Organization/International Agency for Research on Cancer already classifies radiofrequency (RF) electromagnetic fields “*as possibly carcinogenic to humans (Group 2B)*”. Some experts suggest RF radiation should be upgraded to Group 2A, ‘probably carcinogenic’, or even Group 1 ‘carcinogenic’. [Research also indicates that 5G frequencies and other millimeter wavelengths can be biologically active even at very low intensities].

Mains frequency magnetic fields too are presently classified as group 2B carcinogens (WHO/IARC 2002), and there is evidence that excess electrostatic charge and mains frequency electric fields [at levels encounterable in many indoor environments] can, at least indirectly, negatively impact health. Studies have additionally shown that the types of lighting and glazing that are specified can have marked biological effects. Again, healthier solutions can be specified and/or created.

Such findings indicate that a strong opportunity exists for the building industry to be better educated on how to optimise exposures, create “Win/Win situations”, and protect against risk.

There is a need to reduce “electromagnetic pollution”
This present initiative helps address the need to optimise biological performance through intelligent design and create safe environments for individuals who are electromagnetically hypersensitive (EHS) or otherwise adversely affected by electromagnetic pollution. It additionally helps aid productivity, fosters wellbeing, better protects the environment, and creates fertile ground for bio-friendly innovation.

[As an aside, “electromagnetic pollution” also hampers the effective use of technology. IEEE SPECTRUM reports electronic noise is drowning out the Internet of Things, and will become a very expensive problem to deal with unless action is taken now].
Estimates for the number of individuals with EHS vary, with several countries reporting it may affect between 4-10% of their populations. In the UK alone this would correspond to approximately 2.5 to 6.3 million people, a number well in excess of the 1-2% of its population using wheelchairs for which the building industry already makes provisions.

Other members of the community are also considered by some experts to be at higher risk from exposure. It is our duty to create inclusive environments that minimise / avoid such risks and act to actively improve wellbeing.

Need to design in inclusivity and wellbeing initiatives into projects
The WELL® Building Standard already takes into account the need for EMF-protected design. It is becoming increasingly important that we seek to intelligently optimise the electromagnetic characteristics of our designs to address such matters.

Best practice can help ensure that the environments and technologies we design and/or specify in this “Bioelectromagnetic Age” aid social cohesion and comply with the United Nations Sustainable Development Goals (SDGs).

Liability issues
Many insurance companies are now refusing to cover claims linked with electromagnetic radiation. It is vital that we are in the forefront in addressing such challenges, and use this occurrence as a springboard for beneficial change and innovation in our industry.

Legal action and ruling issues
There have already been legal actions and rulings won relating to the effects of electromagnetic pollution. Cases appear likely to greatly increase unless proper proactive measures are put in place.

Stakeholders
Stakeholders in this issue include: building professionals; medical doctors; members of the general public (including those who are EHS); scientists; manufacturers; ministries of health; NGOs; product designers; and technology companies.

‘Win/Win’ situations are possible, and can raise the accomplishments of Intelligent and Responsive Buildings to a whole new level.

We have a duty to our future selves to develop robust policies and practices that will help continually improve the health and wellbeing of individuals and the environment.

12.3. Future scenario

In 10 years' time we wish to be in a position where "bioelectromagnetic environmental issues" are openly addressed in the design of buildings, technologies and environments, with ongoing best practice involving multiple stakeholders continually seeking to refine and improve measures taken.

By that time it is intended that many buildings will have biologically optimised "low anthropogenic EMF zones" (so called "white zones") as standard, as will the infrastructures that allow people access to them. Some may also feature special "bioelectromagnetic climates" that further aid individual wellbeing and performance.

3D EMF design templates

It is envisioned that 3D EMF templates will be used as standard as spatial planning tools to help reduce individuals' exposures to "electromagnetic pollution".

Optimised exposures to electromagnetic phenomena

Exposures to electromagnetic phenomena will be fine-tuned (wherever possible) to aid circadian rhythms, general biological functioning, and task performance.

The effects of electromagnetic phenomena will be taken into consideration as standard, as will the need to have key areas and green infrastructures free from "electromagnetic pollution" to help cater for those who have become sensitive to electromagnetic phenomena, those who wish to live in more natural electromagnetic environments on a daily basis as a matter of personal choice, and those wishing to have "digital detoxes".

It is intended that "white zones" / biologically optimised exposure zones will be provided as standard in many public spaces including, health centres, hospitals, grocery stores, petrol stations, libraries, parks, theatres, etc., to permit inclusive design that caters for those who are EHS. It is also intended that 'white zones' will be created within housing developments, workspaces, etc., for similar reasons.

It is expected that in 10 years' time, provision of external low-EMF green space and low-EMF green corridors will become a design norm as we learn to work more in harmony with nature, rather than against it, and gain greater understanding of the electromagnetic nature of all life. Ideally by this time period, all technologies will be transitioning to more bio-friendly versions of their former selves.

[With proper planning such initiatives can also contribute towards electromagnetic pulse (EMP) protection. At present little is done to counter such threats in the design of the built environment, even though they are Tier 1 risks. It is suggested that ≥20% of all developments should be low EMF and EMP-shielded with on-site power generation. Such provision will significantly improve national security and resilience].

It is envisioned that bioelectromagnetic design skills and EM shielding skills will be in high demand.

12.4 Development strategy

Much of what needs to be known to create safer, more "bioelectromagnetically friendly" buildings, environments and technologies is already known. A great deal of this intellectual challenge is already solved, or provides strong clues as to what areas of investigation need to be taken to determine the best solutions. The opportunities for game-changing innovation are virtually endless.

The willingness to open our eyes to the exciting opportunities that exist is all that is required to take the first step into a brave new future.

12.5 Research Contribution

R&D can make substantial contributions through bringing together and linking knowledge and best practice from all around the world on areas that can impact “bioelectromagnetic health”. It can also be of tremendous service in testing theories and refining what is already known. It is predicted that funding such areas will provide a sound return on investment for those interested in creating a more bio-friendly world.

12.6 Research Agenda

The worldwide research agenda is to assemble interdisciplinary teams of renowned experts and suitably qualified additional stakeholders to blend cutting-edge biological research with technological innovation, international best practice and “real world” needs.

Work required includes detailed investigation of the potential beneficial and detrimental effects of exposures to a wide variety of electromagnetic phenomena, and best practice standards that exist to date. Luckily much initial work in these areas has been undertaken and it provides us with indications of what is required to progress still further with good chances of success.

It is envisaged that such a wide-scale interdisciplinary international effort will reveal numerous potential technical breakthroughs and best practice improvements that can substantially enhance the design and operation of intelligent and responsive buildings. With the air of openness and international unity being encouraged for this topic, and the great breakthroughs that are likely, it is envisaged that cooperation between research and practice will be high.

The ‘Win/Win’ situations that are achievable can raise the abilities and performance characteristics of Intelligent and Responsive Buildings to a whole new level. They can also change the face of technology as we know it. The Dawn of the “Bioelectromagnetic Age” is upon us.

Conclusions

Derek Clements-Croome

The Roadmap has distinctive themes which set the pathway for the future.

WHAT ARE INTELLIGENT BUILDINGS?

Intelligence has three parts cognitive, emotional and practical. A building needs to reflect this. So an intelligent building will responsive to people in terms of not only being functional but to the human senses besides serving a community in the location. It will be resource effective in terms of energy , water and waste with low pollution. It will be smart in terms of technology selected to enable the systems to respond effectively but also make them easier for people to use. Today there is a focus on health and wellbeing and so intelligent buildings must produce a healing environment. Buildings need to be functional and practical but also expressive. Equally important is the infrastructure that services buildings and the people moving between them.

LESSONS FROM HISTORY

Intelligent buildings are not new. Various periods in history just express them in different ways. Vernacular architecture shows how people from all parts of the world have adapted to working and living in all sorts of climates. From the igloo in the Arctic to yurts in Mongolia and the Malaysian house all are examples. The wind towers and mashrabiya in Islamic architecture show how natural ventilation and shading can be achieved in a natural and aesthetic way. The basic principles of passive design are embedded here in the vernacular across the ages and is highly relevant today in order to reduce energy consumption. These basic principles remain true today even for highly smart buildings endowed with high technology.

LESSONS FROM NATURE

Biomimetic architecture uses Nature as the inspiration because it is economic in use of energy and materials. Whether it is spiders webs that stimulated Frei Otto to build lightweight tension structures or the radiolarian which were in Buckminster Fuller's mind for his designs of geodesic domes besides many more examples leads us to believe Nature has an abundance of examples which can inspire architecture. Bernard Rudofsky's book in *1964 Architecture without Architects* is a reminder of this belief.

Biophilia is our innate love of Nature and it can calm and soothe working or living conditions so they are less stressful.

Bio- facades using smart bricks embedded with microbes that generate electricity; chemo luminescence---like the fireflies or angler fish-- for lighting without electricity ; algae living walls to harvest and derive bio- gas; use of walls with artificial leaves using photosynthesis to generate hydrogen are just some ideas.

BUILDINGS FOR PEOPLE

Our designs affect people's physical, mental and social wellbeing. The environment with other factors is a significant cause of absenteeism and presenteeism which in the UK cost about £100bn a year So for many reasons including productivity the intelligent building must be a healthy place to live and work. The latest work by World Green Building Council and their regions; BCO and others are reviewing the methods for rating health and wellbeing including the WELL Standard, Fitwel and Flourish models among others which give a holistic assessment of physical, perception and economic factors.

ROLE OF TECHNOLOGY

The rapid pace of technology and the opportunities it offers cannot be ignored. However there are downsides too . Buildings need to focus on simplicity not complexity. The Fourth Revolution is underway and robotics; quantum computing; internet of things; smart materials; nanotechnology; 3D/4D printing; artificial intelligence are some of the technologies which are already impacting architecture. Intelligent buildings need to be adaptable to change to use the opportunities offered by these technologies for new and old buildings.

SUSTAINABLE ARCHITECTURE

Effective and efficient use of resources like energy ,water and waste is vital so CO2 emissions and pollution are low. Low or neutral carbon buildings can be improved so we see the emergence of carbon positive buildings. Buildings can become energy generators.

DECISION MAKING

At every stage in planning, design, construction , commissioning and post occupancy evaluation decisions have to be made which offer continuity from one stage to the next. There has to be a vision. There has to be connectivity between all the stakeholders. The latest work on decision making with respect to 'wicked' problems will be reviewed and a transdisciplinary approach with collective thought advocated using holistic and systems thinking. Success depends on stakeholders collaborating as an integrated team. Long term thinking is essential with an emphasis on value not short term costs.

POST OCCUPANCY EVALUATION OF INTELLIGENT BUILDINGS

We need to share successes as well as failures so we do not keep repeating the same mistakes. Let us be an open forum to learning from each other.

Intelligent Building have existed for thousands of years but different centuries and cultures express them in different ways so what is an intelligent building? Is it one that serves the needs of people in functional ways but is also beautiful not just visually but in the simplicity and sensory ways it achieves these needs. Examples might be an igloo, a Japanese tea house, the Malaysian house or a courtyard design but there are many other vernacular types throughout history each offering ingredients that make up the recipe for the essence of an intelligent building.

In the 21st century intelligent buildings tend to be ones that are very technology driven but already we can see the impact of changes in society in that they need to be responsible for health and well-being of the occupants so bring in a caring and humane approach that offsets the hard faces of construction and technology. Too often an intelligent building is reduced down to the choice of a building management system but there is much more to it than that.

During his lifetime Wotton published two works: *The Elements of Architecture (1624)*, which is a free translation of *de Architectura* by Marcus Vitruvius Pollio, executed during his time in Venice and a Latin prose address to the king on his return from Scotland (1633). Wotton shares authorship of the quote "Well building hath three conditions: firmness, commodity, and delight," with Vitruvius, from whose *de Architectura* Wotton translated the phrase; some have termed his Elements a paraphrase rather than a true translation, and the quote is often attributed to Vitruvius. Today that phrase might be durability, resilience, function and beauty.

Of course these are basic primary needs but they can be interpreted in various ways. Each building will be nuanced in a particular way according to the design team. It is a composition but unlike a music score composed by one mind buildings are a composite of many thoughts from many minds that make up the design team, many educated in different ways too, and therein lies the source of many problems. Attaining connectivity of thoughts to achieve a vision is not easy but when successful is powerful.

Can Intelligent Buildings provide alternative approaches to heating ventilating and air-conditioning and buildings? Lessons from history as well as the natural world show that they can. These feature in Chapters 2 and 3. Throughout history clean air, sunlight, sound and water have been fundamental to the needs of people. Today, sensitive control of these needs may use either traditional or new solutions, or a blend of these, but we have to remember that the built environment is fundamental to mankind's sense of well-being and it is the totality of this idea that we need to understand and value even in this low carbon economy age. Intelligent buildings respect these values for the individual, the business organisation and for society, and we can learn a lot about intelligent buildings by looking at the history of world architecture and seeing how people have adapted buildings to deal with the rigors of climate and the changing face of civilisation. There are also lessons from Nature because animals and plants have evolved to use materials and expend energy optimally in the various changing and dynamic environments across the world in deserts, arctic regions, hot-humid, hot-dry or temperate climates. Similarly buildings are now having to absorb the impact of the technological age, but the implications of climate change and the need for healthy working conditions are now dominating our thinking as people become more knowledgeable about the impacts of the environment not only on ourselves as individuals but also in the context of communities locally and globally .

Intelligent buildings should be sustainable, healthy, technologically aware, meet the needs of occupants and business, and should be flexible and adaptable to deal with change. The life cycle process of planning, design, construction, commissioning and facilities management including post-occupancy evaluation are all vitally important when defining an intelligent building. Buildings comprise many systems devised by many people, yet the relationship between buildings and people can only work satisfactorily if there is an integrated design, construction and operational team possessing a holistic vision working together from the commencement of a project. To effect a common vision, it is essential for architects, engineers and clients to work closely together throughout the planning, design, construction and operational stages of the buildings total life cycle. This means that planners, consultants, contractors, manufacturers and clients must share a common vision and set of intrinsic values, and must also develop a single understanding of how the culture of an organisation with its patterns of work are best suited to a particular building form and layout when served by the most appropriate environmental systems. A host of technologies are emerging that help these processes, but in the end it is how we think about achieving responsive buildings that matters. Intelligent buildings can cope with social and technological change and should be adaptable to short-term and long-term human needs, however, from the outset this must be delivered through a vision and understanding of the basic function of the building.

We need to consider how buildings affect people in various ways. They need to be expressive as well as being functional. The environments they create can help us work more effectively because they can present a wide range of stimuli for our senses to react to besides satisfying our primeval needs of warmth, safety and security. Intelligent buildings are designed to be aesthetic in sensory terms including being visually appealing; they are buildings in which occupants experience delight, freshness, a feeling of space, they should invite daylight into their interiors, and should provide a social ambience which contributes to a general sense of pleasure and improvement in mood. In Chapter 4 I introduce the idea of flourishing environments. Of course the culture, the management and job satisfaction are key but this does not subdue the importance of the built environment.

Buildings consume a great amount of energy and water in their construction and during their total life-cycle. They use large quantities of materials and aggregates and generate waste and pollution at every stage of their production. It is no longer acceptable to consider a building and its systems in isolation from its social impacts. This becomes critical with the growth of megacities which is part of a rising trend towards urban living. Modern liveable cities comprise intelligent and sustainable buildings and infrastructure however they should be designed to show respect for the natural environment and the health of the inhabitants. Sustainable and intelligent cities are composed of buildings supported by intelligent infrastructures created for the well-being of residential, commercial and industrial communities.

The key criteria for achieving good quality intelligent buildings are:

- *Satisfying client and supply stakeholder objectives and needs;*
- *Meeting social and environmental needs*
- *Recognition of available resources.*

An intelligent building starts with a good client brief and should comprise of:

- *A clearly articulated project vision and mission;*
- *A recognition of the planning, design and procurement realities*
- *Clarity about the use of a whole-life value approach.*

By using integrated design teams and user centric design buildings will have effective connectivity in terms of the occupants and the material resources.. Sustainability and a focus on people adds value. Lessons for Nature and passive architecture together with the judicious use of innovative technology can enable flexibility and an economic use of resources.

The creation of shared visions, effective teams, clear structures and robust processes ensures that the intelligent building being constructed will demonstrate the purpose for which it was conceived. Times are certainly changing so there needs to be an outlook by the project team which is long term and not just short-term. In a way this Roadmap is about change as reflected in society besides the advancements in technology that we create.

CIB General Secretariat
Van der Burgh weg 1
2628 CD Delft
The Netherlands
E-mail: secretariat@cibworld.nl
www.cibworld.nl

CIB Publication 415 / ISBN 978-90-803022-9-7

The Journey Towards Creating Intelligent Buildings

Keywords: IoT, AI, Human; Design; Intelligent

Author 1: Prof. Derek Clements-Croome
Author 2: Matthew Marson
Author 3: Tong Yang
Author 4: Peter McDermott

Working Commission W098 – Intelligent and Responsive Buildings

Abstract – Word Count: 207/300
Advances in technology in recent years have started buildings on their journey towards becoming Intelligent Buildings. However, the success of implementations has been limited by poor articulation of the benefits, change management and limited integration to business systems. Our changing expectations on what digital services and what the built environment should offer us are compounding the experience and promise gap of Intelligent Buildings further.

The rapid adoption of Design Thinking methodologies by corporates is steering organisations, as well as their built environment designers, to concentrate on human needs above technology specifications. The biggest gains are being seen in health and wellbeing, productivity leakage and brand enhancement. Energy and space optimisation, however, provide the financial justification to concentrate on the people aspects of a building.

Platform players are adding enhanced functionality to their large-scale systems and Intelligent Buildings terms and features are gradually becoming more prevalent in common parlance. Specific applications of Internet of Things (IoT) devices and associated Artificial Intelligence (AI) techniques to the built environment are starting to demonstrate value to businesses and societies.

1. Introduction

Intelligent Buildings have existed for thousands of years but different centuries and cultures express them in different ways so what is an intelligent building? One interpretation is that it serves the needs of people not only in functional ways but is also beautiful not just visually but in the simplicity and sensory ways it achieves these needs. Examples might be an igloo, a Japanese tea house, the Malaysian house or a courtyard design but there are many other vernacular types throughout history each offering ingredients that make up the recipe for the essence of an intelligent building.

In the 21st century intelligent buildings tend to be ones that are very technology driven but already we can see the impact of changes in society in that they need to be responsible for health and well-being of the occupants so bring in a caring and humane approach that offsets the hard faces of construction and technology. Too often an intelligent building is reduced down to the choice of technology or a building management system but there is much more to it than this (Clements-Croome 2013, 2019).

The intelligent buildings world is rich in rhetoric around digital transformation and the business value associated with it. But the rhetoric often hides the fact that there are few real-life applications to demonstrate this. Many organisations are restricted by a 'silo structure' that prevents them from being able to deliver smart buildings. Buildings data must be integrated with the systems that are currently operating within the business to see if there is a material gain, and therefore a business case, to deploy smart technologies to the built environment.

This paper will demonstrate examples of Intelligent Buildings deployments and consider practical next steps in realising the Intelligent Buildings of the future. A roadmap for delivering scaled construction specifications will be presented (Clements-Croome, 2018). This paper will present a methodology for the design of intelligent building, an analysis of the technologies in play, some examples of where they have been applied and some future-gazing.

1.0 A New Way to Design an Intelligent Building: Design Thinking

Smart technology and the Internet of Things (IoT) are becoming mainstream, bringing with them design-thinking for a smart built environment that demands a different way of approaching projects. Where it was once possible to design a building or service according to technical requirements alone, it is now necessary to design with relentless interrogation of what the end-user needs.

That's where ethnography comes in. Ethnographic research, traditionally associated with the work of anthropologists and social scientists, is concerned with the systematic study of people and cultures. Qualitative in many respects, this type of research has been peripheral to the design of buildings and buildings services and, until now, it has been considered largely the preserve of architects and mobile app user-experience (UX) designers.

More than simply field research, ethnography involves observing or interacting with the users of a building or digital service as they go about their everyday business - creating an access badge to enter an office building or ordering an item for home delivery from a store app, for example.

Drawing together technical engineering standards, with businesses processes, and the findings of ethnographic research is difficult. True innovation is never simple, but as many in the intelligent buildings field are aware, the benefits are undoubtedly worth the effort.

1.1 Help the client design what they need

For corporates, intelligent buildings are so new, and so different to the normal way of working, that companies are sometimes unaware of what can be achieved. There is a tendency to focus on the technology itself, rather than what that the technology can do for the organisation. Corporates sometimes look at megatrends, such as artificial intelligence and the use of big data, and believe that's what they must have in their organisation, regardless of whether, or how, it will be useful to them.

In fact, it can be difficult to dissuade clients from looking outward at new technologies and sideways at the activities of their competitors, yet they need to look inward to find opportunities for intelligent innovation with the built environment. By focusing on the needs of a specific team, or a specific customer, they often can extrapolate what is required to increase the productivity of their business as a whole.

Technology is undoubtedly part of the solution, but it is only one component. Design thinking that knits technology firmly into the fabric of an organisation and the way its people work, is critical to the amount of value that results from smart buildings and services.

1.2 How does design thinking generate value?
Businesses frequently consider their corporate estate departments as a cost centre that is necessary to keep the business running, but does not deliver any value. They rarely think about what they want people to feel when they are using the buildings, either as a workplace or as a visitor. They fail to see how this might generate value.

Ethnography is useful in this context and can constitute the first step of a smart building strategy. By taking a set of different types of building users and tracking their touch points throughout the day - whether these are actual physical parts of the building or whether they relate to policy and procedure, such as signing into the building and leaving it - we find out where the built environment, and the systems relating to it, either enhance or reduce productivity.

Coupled with this, by standing in the building user's shoes, we can find out what happens when they are in the building and how they generate value. In a building that houses a financial services organisation, for instance, value could be related to the number of transactions settled in an hour, whereas in a creative agency it might be about the conversations that lead to a successful advertising campaign.

These are very different circumstances that might happen into two identical buildings. Yet by starting the buildings engineering and digital services design analysis by looking at the human challenge, rather than the building itself, it's possible to see how a very different strategy might serve each of these very different types of business.

1.3 Design-thinking as technology driver
Design-thinking is about looking at a building through different lenses. One view offers a picture of what employees want from their built environment, another shows what organisations want from their built environment, a third shows how customers can benefit. Technology is the engine of a smart environment, but design-thinking is the driver that guides it, keeps it running, and gets the best performance out of it.

It is easy to see from this calculation how an environment that enables employees to do their best possible job can boost productivity. Only design thinking can lead to the fully-integrated smart buildings that deliver in this way.

2.0 Convergence of key technologies via BIM
Disruptive technologies such as IoT (Internet of Things), Big Data, AI (Artificial Intelligence), and DLT (Distributed Ledger Technology) are being incorporated together with BIM (Building Information Modelling/Management) to improve the efficiency, productivity, and trust in the AEC industry.

According to Nakamoto (2018) DLT represents technologies that distribute records or information amongst all users either privately (permissioned) or publicly (open). One type of DLT is the blockchain, which is originally invented to create a peer-to-peer digital currency (Bitcoin) in the financial sector. Through creating and managing a decentralised database for all parties involved, blockchain has a balanced trade-off between being fast, open and secure.

Blockchain-based smart contracts, in the form of digital contracts that enforced by computer code to mimic the traditional contracts' functions, would benefit the AEC supply chains where frequent transactions occur allowing automate approvals, calculations, and other transacting activities for speedy staged processes and risk management. Another application of blockchain technology is QUANT, which allows engineers to connect on a global level, and provide assistance to one another when required, which is a direct creation of value through human productivity and upskilling for the global engineering workforce.

Implementation of BIM Level 2 (NBS 2014, 2018) facilities full collaboration amongst project contributors – sharing with each other models for their own particular scope of work in a CDE (common data environment). The generation and management of distinct 3D information models (graphical digital prototype of a physical building and non-graphical information) of a construction project incorporating information on the Time Management (4D) and the Budget Calculation (5D) allow project contributors to be well-informed of one another's activities to work towards a common project success goal.

Current advancing digital technologies enable the creation of a virtual model, a database of structured information of a real-life asset, handling and sharing of digital information during the building's lifecycle - Asset Life Cycle Management (6D). Full collaboration and full integration in a cloud based environment are required in achieving BIM Level 3, so that the 'digital twin' can be collaboratively used to interrogate a range of key performance criteria e.g. innovative design, cost, carbon emission, waste, energy use, and future adaptation by all project participants contributing towards a circular economy. It is termed as 'The Blockchain of Circular BIM Things' (Kinnaird et al. 2017) and illustrated in Fig.1.

Built on the communication layer (the internet), the blockchain layer offers better transparency, fairness and accountability amongst all stakeholders. Automated high-quality data collection and distributed processing through the connected sensors and remotely controlled objects enable Big Data Analytics extracting social, environmental and economic values to inform and improve future design.

BIM generation designers are happily immersed in the digital world with better understanding of the overlapping groups of complex systems in buildings, cities and the built environment. Rapid evolving innovative technologies enable open and secure data/information/process management; knowledge discovery efficiency, machine learning, robotics and offsite construction all contribute to boost productivity in the AEC industry.

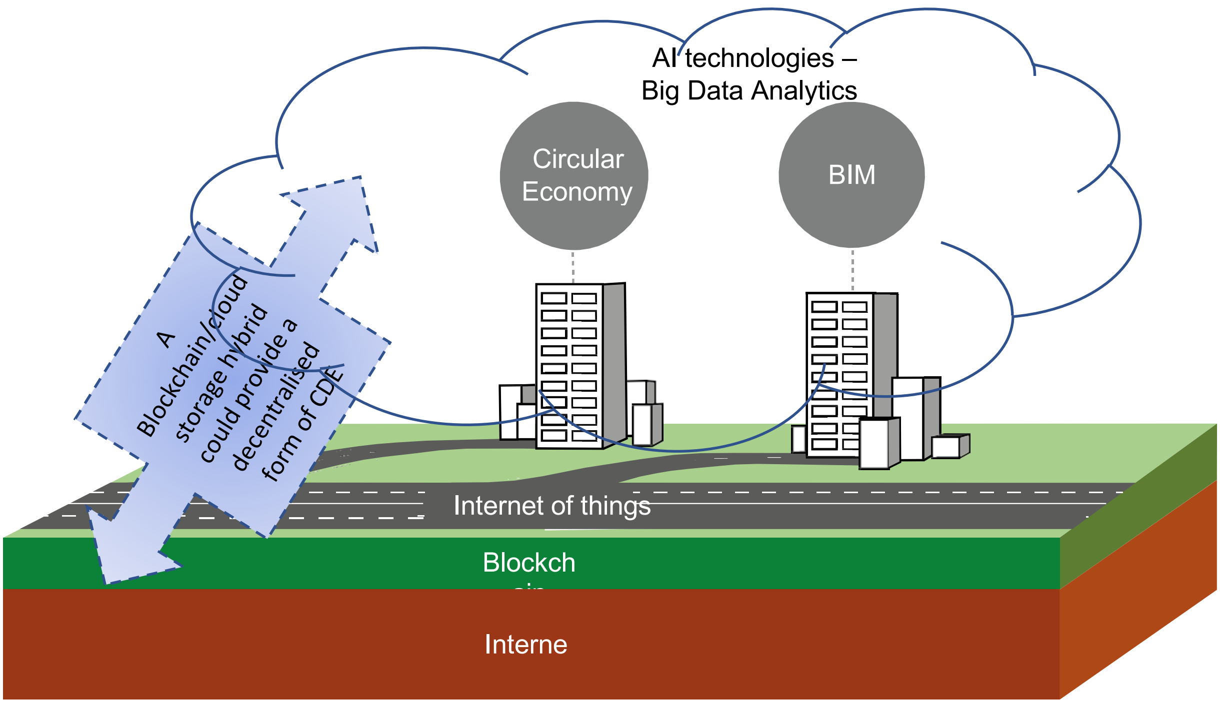


Figure 1. The Blockchain of Circular BIM Things (after Kinnaird et al. 2017)

3.0 Technologies that have been applied

Corporate Real Estate (CRE) functions are considered to be cost centres by most businesses. This is an outdated view because smart buildings mean that, workspaces can help to deliver the fundamental goals of increasing revenues and reducing costs.

This is amply demonstrated by The Edge, an office complex designed and built for the consultancy firm Deloitte in Zuidas, Amsterdam's business centre, The Edge is currently regarded as one of the world's most smart buildings and it is credited with helping Deloitte to attract new talent and reframe its brand.

Studies of similar spaces have demonstrated that workspace quality can help increase job satisfaction by more than 20%. (CABE & BCO, 2015). Improved innovation and better collaborative outcomes (Gensler, 2016), together with increased productivity (Stoddart, 2016) have also been reported. Other benefits include the reduced cost of absenteeism (up to 28% fewer days lost according to IWBI 2016), a reduction in the actual amount of space required for a workforce (up to 29% according to Citrix 2016) and reduced spend on HVAC (heating, ventilation and air conditioning) through improved analytics (up to 25% according to Accenture Digital, 2017).

JLL has modelled that, in the USA, most organisations spend $3 for utilities, $30 for rent and $300 for payroll per square foot, per year (JLL, 2018). These varying orders of magnitude illustrate the importance of acting on people-related issues before energy (Figure 2).

Until now, the focus for cost reduction has been on energy usage is because it has been comparatively easy monitor energy consumption through expenditure. Now that building sensors are coming down in price and cloud computing is more affordable, it is possible to capture more detailed data on some of the other overheads that cost businesses money, however. Some examples follow.

.

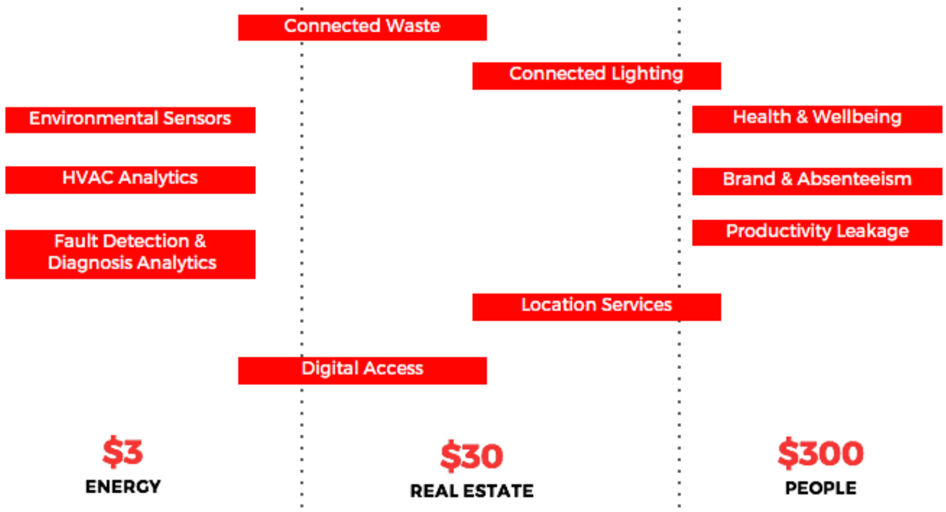


Figure 2: Technologies aligned to the 3/30/300 model

3.1 HVAC Analytics

Most buildings with heating, ventilation and air conditioning (HVAC) systems are controlled using a building management system (BMS). These computers are often rudimentary in their capability, storing on/off times, temperature setpoints and showing alarms when there is a problem with a machine. Given that it collects data about each and every machine connected, the capability of a BMS can often be enhanced. By uploading the data continually to a cloud server, organisations can generate advanced analytics to help improve energy performance.

In the majority of HVAC systems most individual machine elements report back to the BMS. Trending performance over time allows the system to spot deviations from the operational design intent and, in some cases, adapt in real time. Logging data over time allows the system to detect faults before they happen, enabling facilities mangers to respond before they reach alarm status in the BMS. This can save money by improving operational efficiency and removing the need to pay for emergency call-out rates for specialist engineers. Accenture estimates that deployments of this type of analytics results in 10-25% energy savings and 5-15% in maintenance savings. In one example (Figure 3), a leading technology company was able to save $2m USD within just 18 months of its improved analytics system going live.

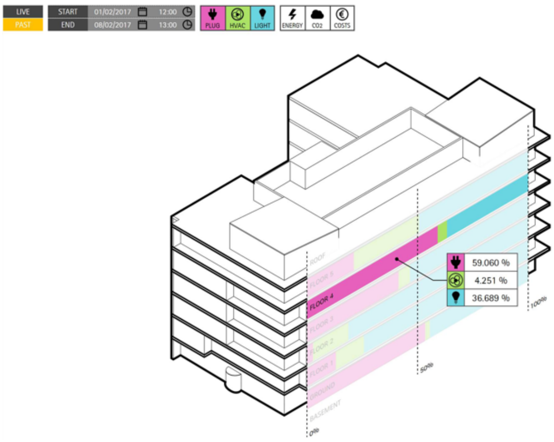


Figure 3: HVAC Analytics Example Dashboard

3.2 Lighting Sensors

Placing banks of sensors within lighting systems is rapidly becoming the sensor deployment method of choice. This is because the ceiling provides a structured grid to place the sensors, and provides easy access to both power and data infrastructure. Given that lighting covers all parts of a workplace floor, there are synergies with the aims of data capture from sensor deployments. Multisensory banks are deployed within the individual luminaire, and capability goes beyond the lighting control. For example, a Bluetooth beacon can be deployed to enable a mesh of location services across the floor plate.

When lighting control is also part of the sensor bank, it means that in most cases 'by the minute' adjustments to light levels are possible are a result of UVA/UVB detection. This is known as 'daylight harvesting' and it usually results in a 30% reduction in energy consumption when the LED is controlled in such a way that only synthetic light is used as a top up to natural daylight. Additionally, ambient light sensors can also be used for task adjustment and this can result in energy savings of around 15%.

Also, occupancy sensors mean that each luminaire can be controlled by presence. This results in an additional 30% saving (to check things from the business case deck) (Ersules, 2016). In addition, the occupancy sensors are also being used as part of more complex space utilisation analytics services (Figure 4) to enable and 10% increase in space utilisation. Locating these within the ceiling means that there is full coverage of a floorplate.

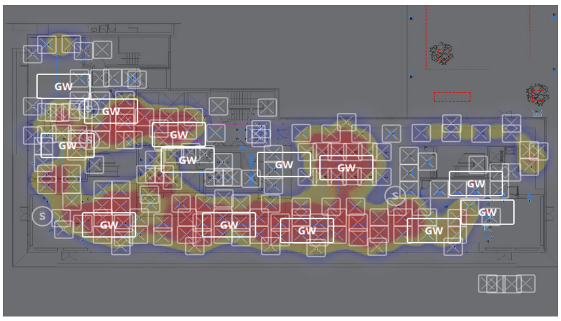


Figure 4: Space Utilisation Example

3.3 Virtual Reality

Increasingly, organisations responsible for the operation of buildings are now using virtual reality alongside BIM models to further understand the root cause of issues within a space. By using the live data available from centres across the building and rendering 3D space, it is possible to understand the complexities of how the space is being used, and how the building is operating in use (Figure 5).

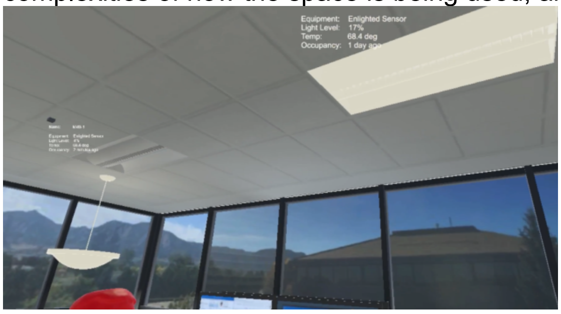


Figure 5: Virtual Reality with Real-Time Sensor Data

3.4 Productivity & Data Integration

Many applications of smart buildings technology promise to offer increased productivity in the workplace. However, simply collecting information about the workplace alone is often not sufficiently valuable without developing a platform that orchestrates the relevant IoT data and can add this into the existing organisational data lake or other databases for analytical comparisons to be made.

Consider the example of the FinTech accelerator business that compared the movements of an individual (captured by using location triangulation on Wi-Fi access points) to the number of patents filed. The client aimed to demonstrate that there would be a positive correlation between collaboration (in this instance physical movement within the space) and innovation – and the supposition. was proven to hold true. It also helped to justify to the business case (previously difficult to demonstrate) that employees whose work was less collaborative, should work from home more often to complete tasks on which they needed to work alone. This would allow the client to increase the desk and sharing ratio based on recorded behaviour, an example of data driven decisions.

3.5 Find A Skill

Knowledge-based firms often struggle to deliver effective collaboration because there is no easy way to find out what skills are available amongst the individuals in the an organisation and where those individuals are is based (Figure 6). In order to make is possible to find skills that a firm already has, a set of location services can be installed across the workplace. In one example, Bluetooth beacons were used as part of a workplace mobile application to match the corporate ‘people directory’, the skills database and locations (derived from the Bluetooth beacons) into a searchable user interface.

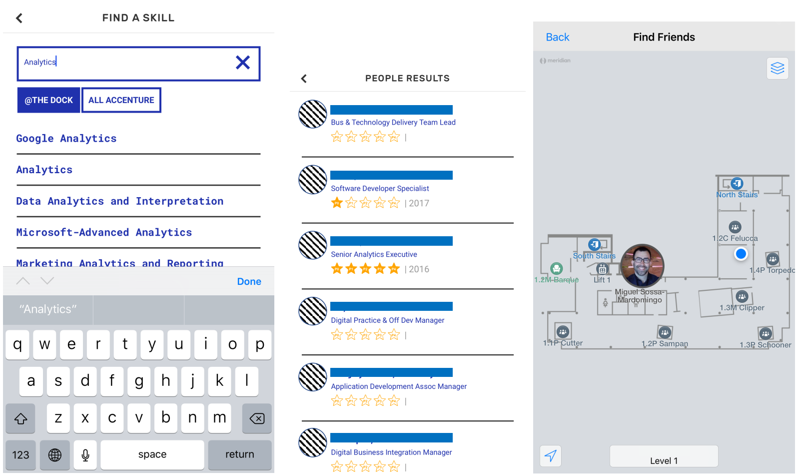


Figure 6: Find a skill mobile application

From the user testing at the client organisation, it was demonstrated that this technology reduced productivity leakage by 15% from most users (Accenture Strategy, 2016). In 2016 Sodexo claims that most white-collar industry workers were susceptible to around two hours of productivity leakage per day (Sodexo, 2016). Productivity leakage is the result of poor management, timings and services within the workplace that prevent an employee from doing something that adds value to the firm. Examples include the cleaning the toilets during their busiest operation, Wi-Fi connections dropping, lifts being out of order due to maintenance during peak traffic hours. Where productivity from innovative technology can manifest itself best, is through enabling increasing opportunities to being productive. Given the fact that productivity is considered differently between organisations and even departments, productivity is difficult to define. It is measured using IoT and cloud computing and acted upon accordingly. In some cases, the IoT and cloud computing used to measure, can also automate responses to observed poor performance.

3.6 Find Me A Place to Meet

As human resources department push the workforce towards increased collaboration, the workplace struggles to physically accommodate meetings in the short-term. A leading technology company deployed a set of occupancy sensors that were located in individual meeting rooms. The data from the sensors was then integrated to a room booking system. This meant that planned versus actual attendance in meeting rooms could be compared for accuracy. In addition to this, live centre data meant the client was able to render live space usage, using a colour-coded system, on both an employee mobile application and public display screens. Spaces that were identified as available, were then bookable immediately for teams to collaborate at short notice (Figure 7).

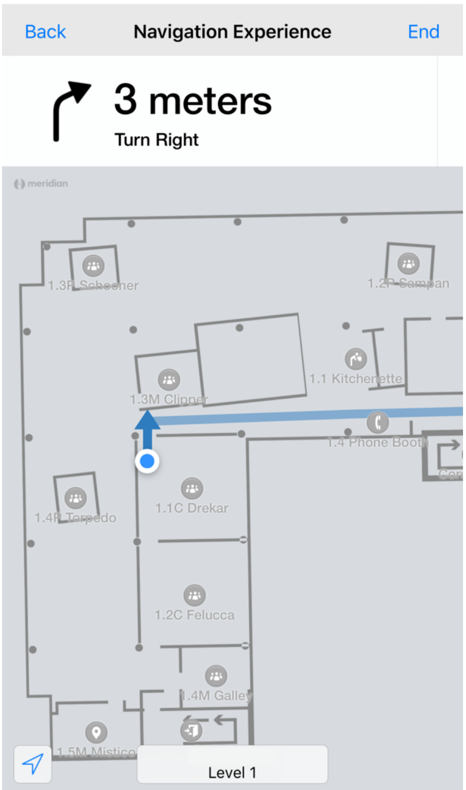


Figure 7: Find a place mobile app

This technology enabled 10% increase in space utilisation (Ersules, 2016), reducing the demand for additional space from the users realising an annual rental saving.

4.0 Conceptual Framework

The impact of digital technology and artificial intelligence on business, automation and communications is transforming the world in many ways. The digital transformation is as significant as the impact of new technology in the agricultural and industrial revolutions.

In the built environment digital technology continues to have a transformative impact. The requirements and forms of many types of building, including shops, factories, offices and homes, are all changing rapidly with the digital revolution. No one is sure where what the destination will look like. Digital village halls? Smart offices? Pop up shopfront showrooms for digital retailers? Social hubs? Living pods? Virtual homes? All established building paradigms are being explored amid a new digital and globalised world. The impacts of climate change and popular unrest caused by inequality and rapid change in economic distribution reflect a more uncertain future.

The increasing prevalence of digital technology in every facet of modern life has included a significant impact on buildings. In fact, some would argue that the term "intelligent building" itself reflects an attempt to define how this innovatory and ubiquitous technology has transformed buildings and construction in the last thirty years.

From early attempts to automate control of buildings using large mainframe digital computers, to the current prevalence of distributed digital controls (DDC) in commercial and now increasingly in domestic buildings, to the redesign of the buildings themselves to reflect the organisational and increased cooling needs of information and communications technology (ICT), these changes have been immense.

Moore's law states that computer power doubles in power every 2 years and even thought this pace of change is set to slow, the new leaps forward in the field of Artificial Intelligence (AI) will soon impact design, construction and operation of digital buildings.

4.1 State of the Art

Most buildings currently use DDC to control their mechanical, electrical and public health (MEP) services. In a typical modern building, small digital computers typically called controllers (DDC), are distributed throughout the building. They monitor and control the local equipment in order to achieve the internal conditions and energy performance required by the occupants and legislation. The digital software applications used in these controllers are normally based on traditional sequential Boolean logic and three term control loops. Fuzzy logic and machine learning programmes are very rare.

In larger buildings, these discrete controllers are networked together with a personal computer or server /client computer system. This provides a human supervisory arrangement usually implemented by a real time graphical user interface. This networked system is called a Building Automation and Control System (BACS) or Building Management System (BMS), sometimes a Building Energy Management System (BEMS). Where the control of the MEP is integrated with other digital systems in the building such as CCTV, access control, fire alarm systems etc., the system is often called an integrated Building Management System (iBMS).

A prominent example of the state of the art is Deloitte's One New Street Square in London. Deloitte have used ICONICS as a Master Systems Integrator in order to link all physical systems with some of their corporate applications. This goes beyond an iBMS. By using an instance of room booking software that Deloitte already owned, in addition to presence sensors deployed across a Zigbee network, the logic stored in the cloud-based software controls the BMS to set back any HVAC or lighting usage if a person is not detected in a space during an active booking.

4.2 Future Scenarios

Several potential development trajectories for digital control of buildings are apparent. Commercial market pressure, user preference and security concerns will determine which approach prevails or dominates in the various applications.

Increasing use of cloud computing, where the digital software is hosted in remote data centres, offers the possibility of building automation as a remote service. Buildings would consist of MEP equipment with appropriate imbedded networked sensors and actuators. The digital intelligence will be provided and hosted offsite and delivered via the internet by specialist providers. These providers could also add value by use of "big data" analytics using machine learning and artificial intelligence (AI) to optimise the performance of building services. This scenario would offer the suppliers the benefits of a service type business model and the ongoing revenues associated with it. For the building owners and users there is the promise of setting business orientated KPIs for the specialist providers while giving them the freedom to focus on their core business. Whether this constitutes a virtual Intelligent building or rather a dumber building that is merely a component of a larger "Intelligent Organisation" is a debatable point.

These technology scenarios are a subset of much bigger those societal changes driven by increasing globalisation, urbanisation, growing wealth in-equality, aging populations, and climate change. The biggest impacts of digital transformation will be the increasing automation of human work, the subsequent redundancy facing many tax paying workers but also possibly prefacing super-abundant production and expansion of leisure time. This will force a paradigm shift in how society organises itself and distributes the fruits of digital production throughout the human population. The big question will be that faced only by the very wealthy in the past: What will we do with our time? These major societal changes will radically change the location and type of work and non-work activities and therefore demand for buildings as well as their type and technical configuration.

4.3 The Difficulties of Delivering an Intelligent Building
There are five key difficulties to consider when delivering an Intelligent Building.

1. **Skills Gap & The Importance of Teaming**
The intelligent buildings industry is currently lacking in formal training and education outside of conferences. Intelligent Buildings hit many skills and markets from construction and mechanical design, to detailed IT systems and app development. Reliance on different third-party suppliers and contractors can strain the overall outcome of how intelligent the building actually ends up. One should take a combinatorial approach by working together - combining engineers, experience designers, technology experts and software developers to stay fully aligned throughout the design process.

The construction industry's 'waterfall'-centred project management methodologies, can often mismatch with software engineers 'agile/scrum' methodologies. Bridging this knowledge gap throughout the design and construction phases is crucial. One should understand that designing architecture that is flexible regarding devices and software enables the building to be at the forefront of innovation when the doors are opened; not just at the initial concept.

2. **Devices & Engineering**
Having company standards for device operation and understanding who will manage device lifecycle and how, is crucial. A transition into IoT protocols like MQTT and away from traditional BacNet and Modbus control protocols enables the efficient use of cloud-based storage and data access.

Instead of creating a network of devices that cannot directly interact, or are on their own controls network, one should rearchitect engineering machines and devices into a single horizontal structure. They can then centrally-controlled on a single IoT platform with the ability to talk to one another. It is important to focus on the design of the core physical controls and IT infrastructure.

3. **Safety & Security**
Operating through an IoT device network and cloud-based data access, can raise obvious security issues. Providing device profiling and pushing toward manufacturer-based device profiles creates a clear overview of exactly what the device's purpose is. When a device is compromised and stops functioning against the set profile, it can then be restricted.

To keep devices secure, one should demand the inclusion best IT practices (such as encryption, certificate-based authentication and updating each device) into the MEP O&M manuals. Disabling unused functionality on each device will also reduce security issues. Many devices have all features enabled to make out-the-box installation and operation easier, but this can mean that backdoors are exploited.

4. **Standards & Connectivity – Matching the Old to the New**
Buildings have been traditionally designed by architects and engineers with very little influence from specialisations relating to 'intelligent systems'. They have also been designed and built without influence from the people who will be using or running them. This can mean the services and connectivity implemented during design and construction phases lacks both the physical and digital platform backbones to integrate the desired service(s) further down the line.

Creating a digital building agenda/aspiration, a corporate specification helps to translate concept to completion across all disciplines. Setting profiles of devices, rearchitecting user and device roles, creating open communication broadcasts and setting a declaration of data ownership for the building can help to build this specification.

Devices are often built towards a slightly tweaked version of RFC/IEEE standards as they are typically being connected to unreliable networks. With intelligent buildings, enterprise devices can be built closely to the original standards, due to the network not having such complex reliability issues. Controls networks are only just starting to allow IT standards for their communication, as a result the design of the controls systems, we must be sensitive to translating old protocols to new, and allow easy update in the future.

5. Data Lake & the Confusion of The Fog

Building system devices are usually designed for local protocols and not cloud-based ones. Helping a system to decide where it should send or retrieve data from can limit data traffic dramatically. For resilience, a level of edge processing is expected in the controller, to pre-process the raw sensor data, and transmit only what is necessary to the cloud. This requires only a fraction of the bandwidth. This hybrid architecture is often referred to as “fog computing”, where the fog is simply a cloud that is ‘close to the ground’. In a fog computing architecture, parts of the cloud (e.g., aggregation) are brought closer to the data source, in order to reduce the demands on the network and the centralised cloud database.

A building technology systems decision can be processed at the edge, the fog or the cloud. These systems are all connected allowing for any device/service/person/place to access data when required, because of successfully segmented data orchestration.

With all this data stored centrally with multilevel access and integration, it breaks the model of needing to understand the infrastructure before being able to create the application within the space. It also allows for raw data to be transformed and used for reporting, visualisation, analytics and machine learning. Understanding this as consultant engineers means that they are able to select, design and specify the right level of controls.

4.4 Recommendations to Counteract the Difficulties

In order to counteract the potential for the difficulties of delivering an Intelligent Building, the below points are recommended as practical means:

- Plan and design with an integrated team so that there is a commitment to the project from all stakeholders Set a clear vision and mission which increases the motivation of the team.
- Apply systems and a holistic thinking.
- Consider the impact of the built environment on occupants and communities. Occupants behaviour has a significant effect on the consumption of energy and water so increase the awareness of occupants to their impact on resources. Aim to increase the build asset value by designing for sustainable operation; flexible and agile spaces; health and wellbeing.
- Use smart metering and wireless sensor technology. Develop data management systems to give feedback on the performance of spaces in the building. Measure the interaction between the building, the systems and the occupants using the latest wireless sensor systems.
- Design for a degree of personal control of the environment.
- Use a whole life value approach to economic evaluations.
- Use technology as an enabler but aim for simplicity rather than over complicated systems but ensure interoperability is in place as connectivity is vital to effect smooth continuous operation
- Remember efficiency does not guarantee effectiveness: you need to consider both when designing systems.
- Design beyond the expectations defined in codes and regulations. Keep abreast of relevant fields of knowledge and innovation which may be occurring in other sectors. Learn from other disciplines across sectors.
- Think of an intelligent building as an organism responding to human and environmental needs. Bio facades are emerging where living and non-living elements are coexisting.

5.0 Conclusions

Intelligent buildings should be sustainable, healthy, technologically aware, meet the needs of occupants and business, and should be flexible and adaptable to deal with change. The life cycle process of planning, design, construction, commissioning and facilities management including post-occupancy evaluation are all vitally important when defining an intelligent building. Buildings comprise many systems devised by many people, yet the relationship between buildings and people can only work satisfactorily if there is an integrated design, construction and operational team possessing a holistic vision working together from the commencement of a project. To effect a common vision, it is essential for architects, engineers and clients to work closely together throughout the planning, design, construction and operational stages of the buildings total life cycle. This means that planners, consultants, contractors, manufacturers and clients must share a common vision and set of intrinsic values, and must also develop a single understanding of how the culture of an organisation with its patterns of work are best suited to a particular building form and layout when served by the most appropriate environmental systems. A host of technologies are emerging that help these processes, but in the end it is how we think about achieving responsive buildings that matters. Intelligent buildings can cope with social and technological change and should be adaptable to short-term and long-term human needs, however, from the outset this must be delivered through a vision and understanding of the basic function of the building (Clements-Croome 2019).

References

Accenture Digital, 2017. Connected Facilities, Boston: Accenture.

Accenture Strategy, 2016. Workplace Productivity Leakage, Copenhagen: Accenture.

Accenture Strategy, 2016. Workplace Productivity Leakage Study, Copenhagen: Accenture.

Accenture, 2013. Defining Success: Global Research Results, London: Accenture.

Accenture, 2018. Robotics Process Automation in Banking, Insurance & Capital Markets. [Online]
Available at: https://www.accenture.com/us-en/insight-financial-services-robotic-process-automation

Allen, J. G. et al., 2016. Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments, Cambridge, Massachusetts: Harvard School of Public Health.

CABE & BCO, 2015. The Impact of Office Design on Business Performance, London: BCO.
Citrix, 2016. Workplace Review, USA: Citrix.

Clements-Croome D J., 2013, Chapter 1 in *Intelligent Buildings* (ICE Publishing)

Clements-Croome, D J., e. a., 2018. Research Roadmap for Intelligent and Responsive Buildings. Delft: CIB General Secretariat.

Clements-Croome D J., 2019, *Sustainable and Liveable Intelligent Buildings* (Crowood Press)

Communications/Ebiquity, C., 2015. Global CSR Study, s.l.: Cone Communications/Ebiquity.

Engin Z. and Treleaven P. (2018) Algorithmic Government: Automating Public Services and Supporting Civil Servants in using Data Science Technologies, The Computer Journal, bxy082, https://doi.org/10.1093/comjnl/bxy082. 11 August 2018.

Ersules, 2016. Engineering Report, Dublin: Ersules.

Ersules, 2016. Ersules Engineering Report, s.l.: s.n.

Everest Group & NASSCOM, 2015. Seizing The Robotic Process Automation (RPA) Market Opportunity, Dallas; Noida: Everest Group & NASSCOM.

Fitbit, 2018. Press Release Details: "Fitbit Reports $571M Q4'17 and $1.616B FY'17 Revenue". [Online]
Available at: https://investor.fitbit.com/press/press-releases/press-release-details/2018/Fitbit-Reports-571M-Q417-and-1616B-FY17-Revenue/default.aspx

Gensler, 2016. Workplace Survey, London: Gensler.

IDC, 2016. IDC FutureScape: Worldwide Analytics, Cognitive/AI, and Big Data 2017 Predictions, Framingham, MA: IDC.

IDC, 2016. IDC FutureScape: Worldwide Wearables and Augmented Reality/Virtual Reality 2017 Predictions, Framingham, MA: IDC.

Investopedia, 2013. The Causes And Costs Of Absenteeism In The Workplace. [Online]
Available at: https://www.forbes.com/sites/investopedia/2013/07/10/the-causes-and-costs-of-absenteeism-in-the-workplace/#24f527d53eb6

IWBI, 2016. WELL, Los Angeles: IWBI.

IWBI, 2017. WELL Standard, Los Angeles: IWBI.

IWBI, 2018. Making the case for better buildings. [Online]
Available at: https://www.wellcertified.com/en/articles/making-case-better-buildings

JLL, 2018. The 3-30-300 calculator. [Online]
Available at: http://www.us.jll.com/united-states/en-us/services/corporates/consulting/reduce-real-estate-costs
[Accessed 9 July 2018].

Kinnaird, C., Geipel, M. and Bew, M. (2017) Blockchain technology – how the inventions behind Bitcoin are enabling a network of trust for the built environment, Arup Foresight report. https://www.driversofchange.com/projects/blockchain-technology-how-the-inventions-behind-bitcoin-are-enabling-a-network-of-trust-for-the-built-environment/

Köhn, R., 2018. "Konzerne verbünden sich gegen Hacker" - Corporations Ally Themselves Against Hackers (sic). [Online]
Available at: http://www.faz.net/aktuell/wirtschaft/diginomics/grosse-internationale-allianz-gegen-cyber-attacken-15451953-p2.html?printPagedArticle=true#pageIndex_1

Li, J., Greenwood, D. and Kassem, M. (2018) Blockchain in the built environment: analysing current applications and developing an emergent framework, Proc. Creative Construction Conference 2018, CCC 2018, 30 June - 3 July 2018, Ljubljana, Slovenia.

Matos, J., 2018. Measuring WELL: ASID post-occupancy analysis highlights the value of designing WELL. [Online]
Available at: https://www.wellcertified.com/en/articles/measuring-well-asid-post-occupancy-analysis-highlights-value-designing-well
Medicine, A. A. o. S., 2009. Better Sleep Is Associated With Improved Academic Success. [Online]
Available at: https://www.sciencedaily.com/releases/2009/06/090610091232.htm

Mckinsey Global Institute (2017) Reinventing construction: a route to high productivity. https://www.mckinsey.com/~/media/McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/Reinventing%20construction%20through%20a%20productivity%20revolution/MGI-Reinventing-Construction-Executive-summary.ashx

Meister, J., 2015. The Future Of Work: Airbnb CHRO Becomes Chief Employee Experience Officer. [Online]
Available at: https://www.forbes.com/sites/jeannemeister/2015/07/21/the-future-of-work-airbnb-chro-becomes-chief-employee-experinece-officer/#7d651c642327

Nakamoto (2018) What's the difference between blockchain and DLT? https://medium.com/nakamo-to/whats-the-difference-between-blockchain-and-dlt-e4b9312c75dd

Nordrum, A., 2016. Popular Internet of Things Forecast of 50 Billion Devices by 2020 Is Outdated. [Online]
Available at: https://spectrum.ieee.org/tech-talk/telecom/internet/popular-internet-of-things-forecast-of-50-billion-devices-by-2020-is-outdated

Phillips, Amsterdam. The Edge, 2017: Phillips.

RICS (2018) Big data, smart cities, intelligent buildings – surveying in a digital world.
https://www.rics.org/globalassets/rics-website/media/knowledge/research/insights/big-data-smart-cities-intelligent-buildings-surveying-in-a-digital-world-rics.pdf

Schoder, D. & Hassan, Q. F., 2018. Internet of Things A to Z: Technologies and Applications. s.l.:Wiley-IEEE Press.

Smith, A., 2016. Gig Work, Online Selling and Home Sharing. [Online]
Available at: http://www.pewinternet.org/2016/11/17/gig-work-online-selling-and-home-sharing/

Sodexo, 2016. Workplace Trends, Issy-les-Moulineaux: Sodexo.

Statt, N., 2016. Boeing is using Google Glass to build airplanes. [Online]
Available at: https://www.theverge.com/2016/7/14/12189574/boeing-google-glass-ar-building-airplane-parts

Stoddart, C., 2016. The Stoddart Review, London: Raconteur.

Unify, 2014. New Ways of Working, Munich: Unify.

The business value of an innovative building

Matthew Marson
Received (in revised form): 12th September, 2018
Tel: +44 20 3057 2281; E-mail: matthew.marson@wsp.com

***Matthew Marson** MEng (Hons) CEng MIMechE FRSA, is WSP's Head of Smart Buildings. He focuses on designing and delivering digital real estate transformation and human-centred Internet of Things (IoT) technologies within the built environment. Matthew trained as an architect and is a Chartered Engineer. He was elected as a Fellow of the Royal Society of Arts in 2017 and named as the Institute of Mechanical Engineers Young Visionary 2016/17 for his work in creating 'The World's Most Connected Building'. Matthew sits on the CIBSE's Intelligent Buildings Group and is a keynote speaker at international industry events. He was a co-author of the* Encyclopaedia of Sustainable Technologies*.*

Abstract

Smart buildings promise to deliver for businesses across a broad spectrum of value levers, but in many cases the technology has been difficult to implement, so it has failed to meet expectations. By considering the trends affecting businesses, including consumer perceptions and the complex delivery process of a smart building, this paper shows how holistic designs can be — and have been — successfully deployed in both new builds and retrofits.

Keywords: digital, smart, intelligent, sensor, data, analytics, business case, value

INTRODUCTION

The smart buildings world is rich in rhetoric around digital transformation and the business value associated with it. But the rhetoric often hides the fact that there are few real-life applications to demonstrate this. Many organisations are restricted by a 'silo structure' that prevents them from being able to deliver smart buildings. Buildings data must be integrated with the systems that are currently operating within the business to see if there is a material gain, and therefore a business case, to deploy smart technologies to the built environment.

Other failures in the adoption of smart buildings technology arise from blinkered views of business. Understanding the macro trends that are changing the fundamentals of a business can help move a conversation with the CFO from cost-cutting to one of investment.

This paper will discuss how the competitive digital landscape, and changing expectations, drive the business case to invest in smart building technology. Understanding the value levers and how they have been applied in real-world contexts demonstrates how to successfully engage with the issue.

THE MEGA TRENDS THAT ARE AFFECTING BUSINESSES

The way that most businesses operate has fundamentally changed due to the development and availability of new digital technologies. In fact, the impact has been so profound that some businesses that were on the Fortune 500 in 2010 no longer feature on the list.

Corporate Real Estate Journal
Vol. 8 No. 2, pp. 1–11

2043–9148

There are six fundamental megatrends that are changing how businesses operate and therefore the spaces that they need to work in (see Figure 1).

Today's workforce is a flexible mix of permanent staff, freelancers, contractors and temporary workers. Businesses need to respond to how they deliver seamless working experiences in what has become known as 'the gig economy'. A 'gig' describes a single project or task for which a worker is hired, often through a digital marketplace, to work on demand. Some gigs are a type of short-term job, and some workers pursue gigs as a self-employment option. Between 2015 and 2016, 8 per cent of Americans were employed through an online gig economy platform.[1] This is attractive to workers, with 43 per cent of employees saying they would choose flexible working hours over a pay increase.[2] It is difficult to deliver an environment that supports this type of working practice without technology.

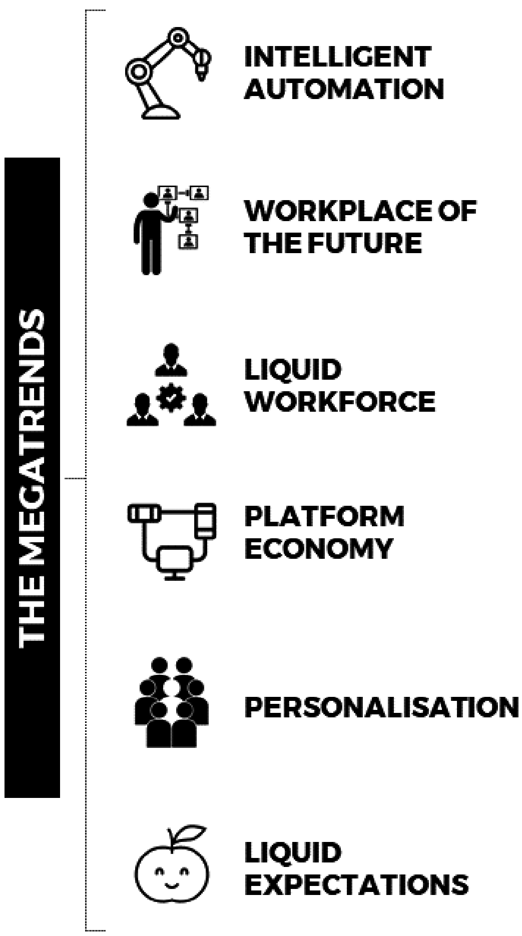


Figure 1 The megatrends
Source: Accenture Digital (2017)

The concept of work–life balance has changed. Fifty-six per cent of global professionals define career success as having a good work–life balance. People are clearly concerned with how they work, with over half of respondents saying they had turned down or not considered a job due to concerns about its impact on work–life balance.[3] In the future, it is expected that employees will blur their professional and private lives even more. As a result, working patterns will alter as jobs become outcome-driven rather than schedule-driven. Employees will also expect flexibility and services to be provided to support them. This is a very different type of workplace design and service delivery.

The use of intelligent automation has been increasing significantly. It is expected that within the next few years, governments will implement specific regulations to preserve human jobs in the face of increased automation. Robotic automation makes it possible to capture and interpret existing applications for processing a transaction, manipulating data, triggering responses and communicating with other digital systems to reduce time taken to perform tasks and lower costs by 80–90 per cent and 80 per cent respectively.[4] The design of a workplace needs to respond to the types of job that humans will be performing.

Analytics — a subset of intelligent automation — is the discovery, interpretation and communication of meaningful patterns in data that can help a business transform into an insight-powered, high-performance enterprise. By 2020, 66 per cent of enterprises will implement advanced classification solutions to automate access, retention and disposition of unstructured content, making it more useful for analytics.[5] This technology promises to help set out business cases that were once considered hard to quantify.

Furthermore, intelligent automation powers the Internet of Things (IoT) — a network of physical devices that collect and exchange data.[6] The IoT permits communication among these devices to create a seamless environment-based experience for a user, blurring the lines between the cyber and physical worlds, delivering experiences and productivity gains. The IoT is ever-growing; the number of interconnected devices increased by 31 per cent year-on-year to 8.4bn in 2017,[7] and this figure is expected to increase to 30.7bn by 2020.[8]

The rise of augmented reality further blurs the line between the digital and the physical. It provides a view of a real-world environment which is supplemented by computer-generated sensory input such as sound, video, graphics or other data. By the end of 2018, it is predicted that 25 per cent of enterprise IT organisations will be testing augmented reality business applications on smartphones.[9] For instance, by using Google Glass, augmented reality eyewear, for wire harnessing, Boeing reduced production time for harnesses by 25 per cent and cut error rates by half.[10]

As demand grows for best-in-class experiences in our private lives, the same level of service can be expected in the workplace. Simply put, employees now expect tailored experiences, fast evolution and personal connection: 79 per cent of millennials think their environment is more important than their paycheque.[11] Corporations know this, and they are responding: Airbnb, for example, has created a Chief Employee Experience Officer.[12]

Healthy is regarded by many as the new wealthy. Consumers are using health monitoring for both leisure and preventative care. Technology innovation has cut the price of biometric monitoring significantly, leading to the rise in popularity of gadgets such as Fitbit, which had 25.4m active users as of 31st December, 2016.[13]

Overall, however, rising healthcare costs are an issue that many governments and firms are struggling to manage. In the US, the total annual costs of lost productivity due to employee absenteeism totalled \$84bn.[14] Yet there is action that firms can take; it has been shown that creating and implementing well-being programmes can reduce employee 'sick days' by 26 per cent.[15]

The office environment has a crucial role to play, with smart buildings showing strong potential to improve employee health and well-being. For instance, at one of its offices, the real estate agency firm Cundall achieved WELL Gold certification for its focus on improved indoor air quality, including continuous monitoring of carbon dioxide (CO_2) and volatile organic compounds (VOCs). This is estimated to have saved the company £200,000 per year through a reduction of four sick days per year per employee and a 27 per cent reduction in staff turnover.[16]

Smart lighting systems, which are designed in line with human circadian rhythms, can also be beneficial. Data from an employee survey after a smart lighting system was installed in a new office revealed that 25 per cent of employees attributed their enhanced sleep quality to the new lighting system.[17] Better sleep improves cognitive function[18] and this can boost employees' productivity at work.

SHIFTING PERCEPTIONS

With the ubiquitous digitisation of services, consumer expectations are blurring the lines between traditional barriers. In the past, companies only considered their like-for-like counterparts to be competitors.

Banking provides a good illustration of how digitisation has shifted perceptions. Traditionally, banks competed with each other to attract customers with their products, services and interest rates. Technology companies disrupted this model by creating new experiences: we can now pay for goods and services using our mobile devices, for example. Services such as PayPal enable us to 'e-mail' money to anyone around the world without the need for complex international account numbers. Monzo, the mobile banking app created in 2015, exploited a gap in the market to improve consumer experience, by making personal finance easier to track.[19] These new competitors have moved the goalposts for traditional banking firms.

What are known as 'perceptual competitors' set out to shape experiences that create new expectations across sectors. And they pose a more acute competitive threat than many marketers may yet have understood. Take the speed of delivery mechanisms, for example. A customer who buys a household item such as a new kettle can often have it delivered the same day, but it can take up to five working days to receive a new debit card from a bank. There is increasing misalignment between the expectations of consumers and the service they receive.

All of this means that people expect the same level of technological sophistication at work as that which they experience regularly in their home lives. With Google and Amazon among the many firms developing smart home technologies, the rate of growth in such expectations can only increase.

COMPLEX DELIVERY PROCESS

Developing smart buildings in the corporate world may have been slow to take off because of the specialist skills required, even though the eventual benefits are so significant.

Very broadly, these are the process steps in a smart-building programme:

(1) Kick-off;
(2) Vision;
(3) Experience design;
(4) Strategy;
(5) Business case modelling;
(6) Devices and machines;
(7) Connectivity;
(8) Edge processing and resilience;
(9) Platforms and big data;
(10) Application;
(11) Business systems integration;
(12) User interfaces;
(13) Deployment commissioning;
(14) Testing;
(15) Change management;
(16) Support models;
(17) Continuing operations.

BUILDINGS AS A STRATEGIC DRIVER VALUE

Corporate real estate (CRE) functions are considered to be cost centres by most businesses. This is an outdated view, because smart buildings mean that workspaces can help to deliver the fundamental goals of increasing revenues and reducing costs.

This is amply demonstrated by The Edge,[20] an office complex designed and built for the consultancy firm Deloitte in Zuidas, Amsterdam's business centre. The Edge is currently regarded as one of the world's smartest buildings and it is credited with helping Deloitte to attract new talent and reframe its brand.

Studies of similar spaces have demonstrated that workspace quality can help increase job satisfaction by more than 20 per cent.[21] Improved innovation and better collaborative outcomes,[22] together with increased productivity,[23] have also been reported. Other benefits include the reduced cost of absenteeism (up to 28 per cent[24] fewer days lost), a reduction in the actual amount of space required for a workforce (up to 29 per cent[25]) and reduced spend on HVAC (heating, ventilation and air conditioning) through improved analytics (up to 25 per cent[26]).

JLL has modelled that, in the USA, most organisations spend $3 for utilities, $30 for rent and $300 for payroll per square foot, per year.[27] These varying orders of magnitude illustrate the importance of acting on people-related issues before energy (see Figure 2).

Until now, the focus for cost reduction has been on energy usage because it has been comparatively easy to monitor energy consumption through expenditure. Now that building sensors are coming down in price and cloud computing is more affordable, however, it is possible to capture more detailed data on some of the other overheads that cost businesses money. Some examples follow.

HVAC analytics

Most buildings with heating, ventilation and air conditioning (HVAC) systems are controlled using a building management system (BMS). These computers are often rudimentary in their capability, storing on/off times, temperature setpoints and showing alarms when there is a problem with a machine. Given that it collects data about each and every machine connected, the capability of a BMS can often be enhanced. By uploading the data continually to a cloud server, organisations can generate advanced analytics to help improve energy performance.

In the majority of HVAC systems, most individual machine elements report back to the BMS. Trending performance over time allows the system to spot deviations from the operational design intent and, in some cases, adapt in real time. Logging data over time allows the system to detect faults before they happen, enabling facilities mangers to respond before they reach alarm status in the BMS. This can save money by improving operational efficiency and removing the need to pay for emergency call-out rates for specialist engineers. Accenture estimates that deployment of this type of analytics results in savings of 10–25 per cent on energy and 5–15 per cent on maintenance. In one example (see Figure 3), a leading technology company was able to save $2m USD within just 18 months of its improved analytics system going live.

Lighting sensors

Placing banks of sensors within lighting systems is rapidly becoming the sensor deployment

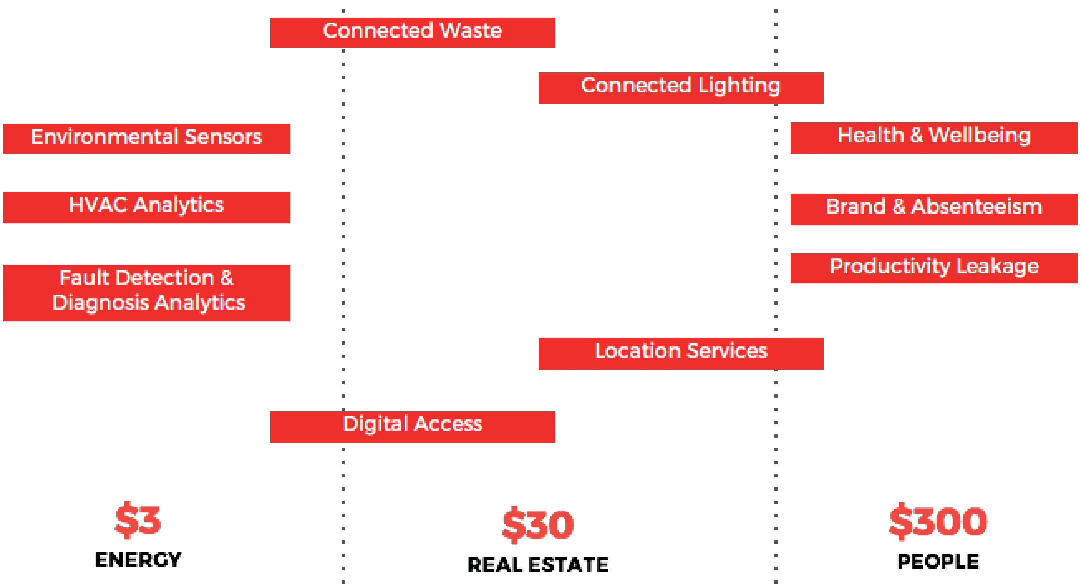


Figure 2 Technologies aligned to the 3/30/300 model
Source: WSP (2018)

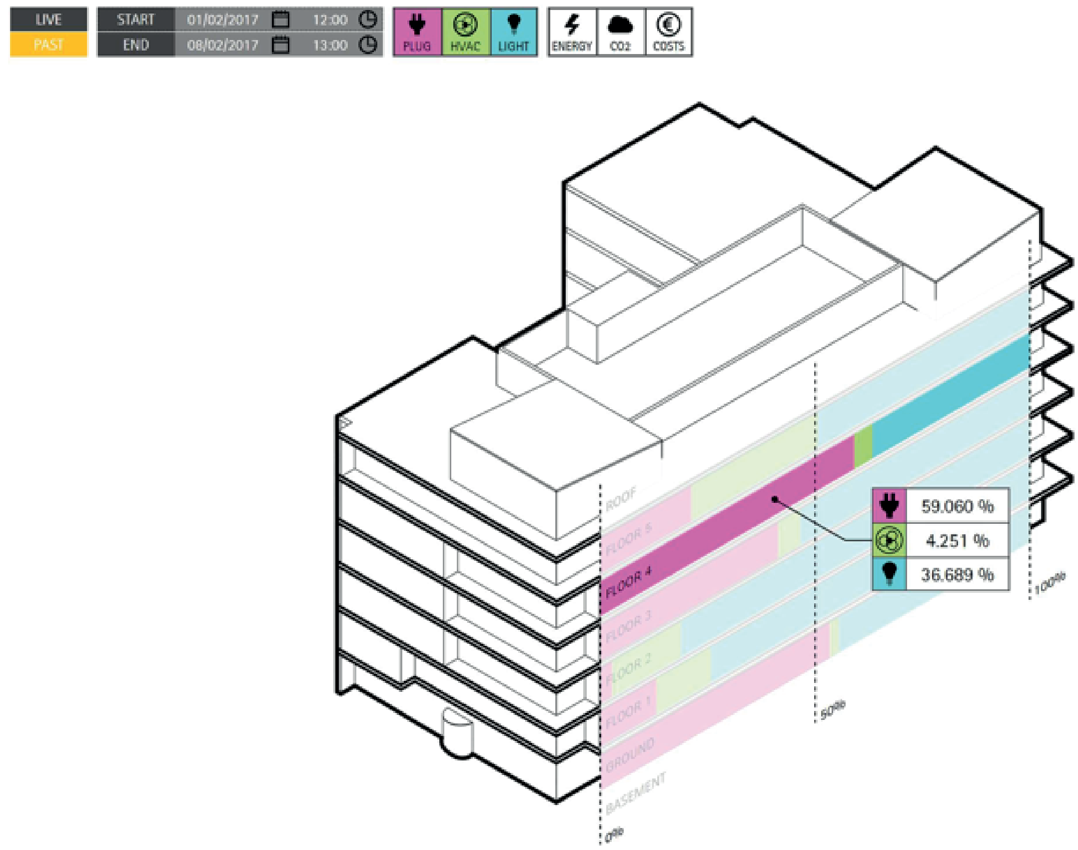


Figure 3 HVAC analytics example dashboard
Source: ICONICS (2017)

method of choice. This is because the ceiling provides a structured grid to place the sensors, and provides easy access to both power and data infrastructure. Given that lighting covers all parts of a workplace floor, there are synergies with the aims of data capture from sensor deployment. Multisensory banks are deployed within the individual luminaire, and capability goes beyond the lighting control. For example, a Bluetooth beacon can be deployed to enable a mesh of location services across the floor plate.

When lighting control is also part of the sensor bank, it means that in most cases ‘by the minute’ adjustments to light levels are possible as a result of UVA/UVB detection. This is known as ‘daylight harvesting’ and it usually results in a 30 per cent reduction in energy consumption when the LED is controlled in such a way that only synthetic light is used as a top-up to natural daylight. Additionally, ambient light sensors can also be used for task adjustment and this can result in energy savings of around 15 per cent.

Also, occupancy sensors mean that each luminaire can be controlled by presence. This results in an additional 30 per cent saving (to check things from the business case deck).[28] In addition, the occupancy sensors are also being used as part of more complex space utilisation analytics services (see Figure 4) to enable a 10 per cent increase in space utilisation. Locating these within the ceiling means that there is full coverage of a floorplate.

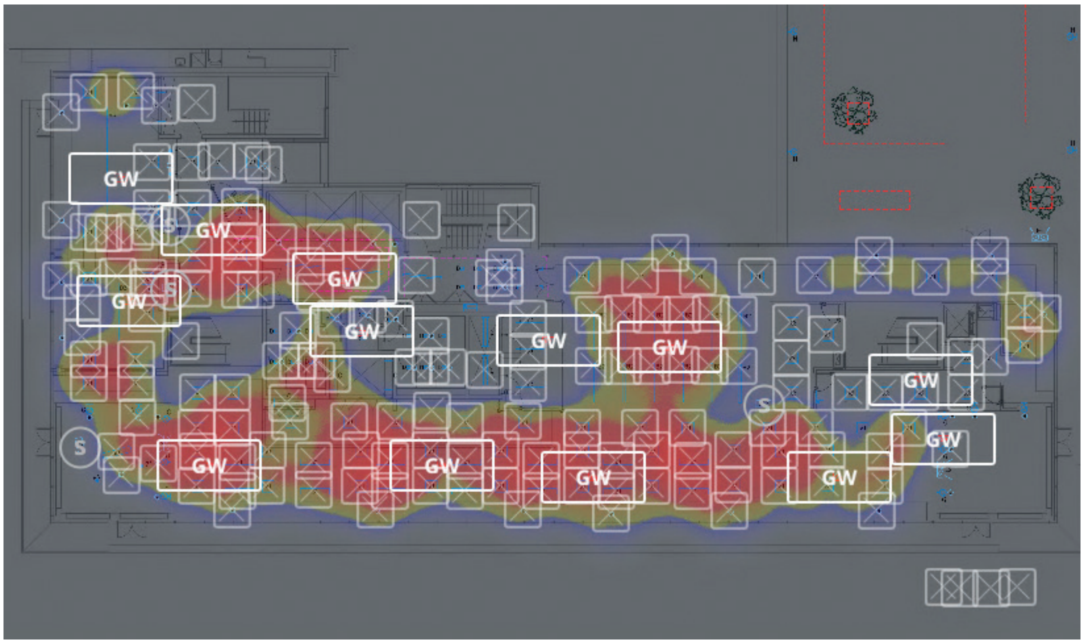


Figure 4 Space utilisation example
Source: Ersules (2017)

Virtual reality

Increasingly, organisations responsible for the operation of buildings are now using virtual reality alongside BIM models to further understand the root cause of issues within a space. By using the live data available from centres across the building and rendering 3D space, it is possible to understand the complexities of how the space is being used, and how the building is operating in use (see Figure 5).

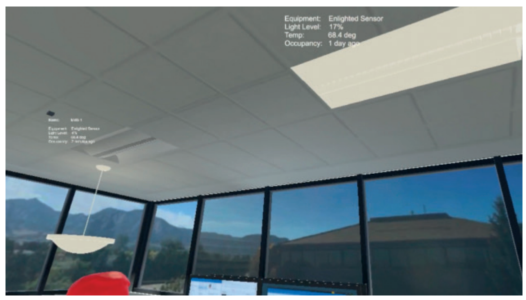


Figure 5 Virtual reality with real-time sensor data
Source: WSP (2018)

Productivity and data integration

Many applications of smart buildings technology promise to offer increased productivity in the workplace. However, simply collecting information about the workplace alone is often not sufficiently valuable without developing a platform that orchestrates the relevant IoT data and can add this into the existing organisational data lake or other databases in order for analytical comparisons to be made.

Consider the example of the FinTech accelerator business that compared the movements of an individual (captured by using location triangulation on Wi-Fi access points) to the number of patents filed. The client aimed to demonstrate that there would be a positive correlation between collaboration (in this instance, physical movement within the space) and innovation, and the supposition was proven to hold true. It also helped to justify to the business case (previously difficult to demonstrate) that employees whose work was less collaborative should work from home more often to complete tasks on which they needed to work alone. This would allow the client to increase the desk and sharing ratio based on recorded behaviour — an example of data-driven decisions.

Constantly temporary

The demands of a fluid workforce, bringing different skills to the workplace, together with increasing project work in many industries makes the design of workspaces challenging. Providing a work setting that is the same for everyone leads to high levels of dissatisfaction, because it is not perfect for anyone.

Faced with this challenge, a leading international management consultancy responded with a workplace design that used an architectural paradigm called 'constantly temporary'. Essentially, this meant that everything was movable, and often mounted on wheels: regular work desks, display screens for collaboration, or even temporary installations (such as virtual reality demonstration space).

To achieve this, the building needed to be designed with an entirely smooth floor area to enable ease of movement of all items of furniture. To supply power and wired data connections to the desks and other pieces of technology, 'ninjas' (black cables from the ceiling) were installed over some of the building services to allow for complete flexibility of the space. This also meant that users could customise their immediate vicinity with a high degree of flexibility.

When a new project comes into the workplace, the team is given an area for a 'structural bay' to accommodate the size of the team. The team selects the furniture that they require, and it is provided for them. The flexible mechanical and electrical services mean that the space can be rapidly commissioned to meet the changing needs of new projects.

One of the drawbacks is that when an entire workplace is in constant flux, it can be difficult to locate people and things.

To address this issue, the client developed a workplace mobile app and placed a set of internal location services to allow users to quickly find what they were looking for.

Find a skill

Knowledge-based firms often struggle to deliver effective collaboration because there is no easy way to find out what skills are available among the individuals in an organisation and where those individuals are based (see Figure 6). To make it possible to find skills that a firm already has, a set of location services can be installed across the workplace. In one example, Bluetooth beacons were used as part of a workplace mobile application to match the corporate 'people directory', the skills database and locations (derived from the Bluetooth beacons) into a searchable user interface.

From the user testing at the client organisation, it was demonstrated that this technology reduced productivity leakage by 15 per cent from most users.[29] In 2016 Sodexo claimed that most white-collar industry workers were susceptible to around two hours of productivity leakage per day.[30] Productivity leakage is the result of poor management, timings and services within the workplace that prevent an employee from doing something that adds value to the firm. Examples include cleaning the toilets during their busiest operation, Wi-Fi connections dropping, lifts being out of order due to maintenance during peak traffic hours. Productivity from innovative technology can manifest itself best through enabling greater opportunities for being productive. Given the fact that the concept is considered differently between organisations and even between departments, productivity is difficult to define. It is measured using the IoT and cloud computing and acted upon accordingly; in some cases, this method of measurement can also automate responses to observed poor performance.

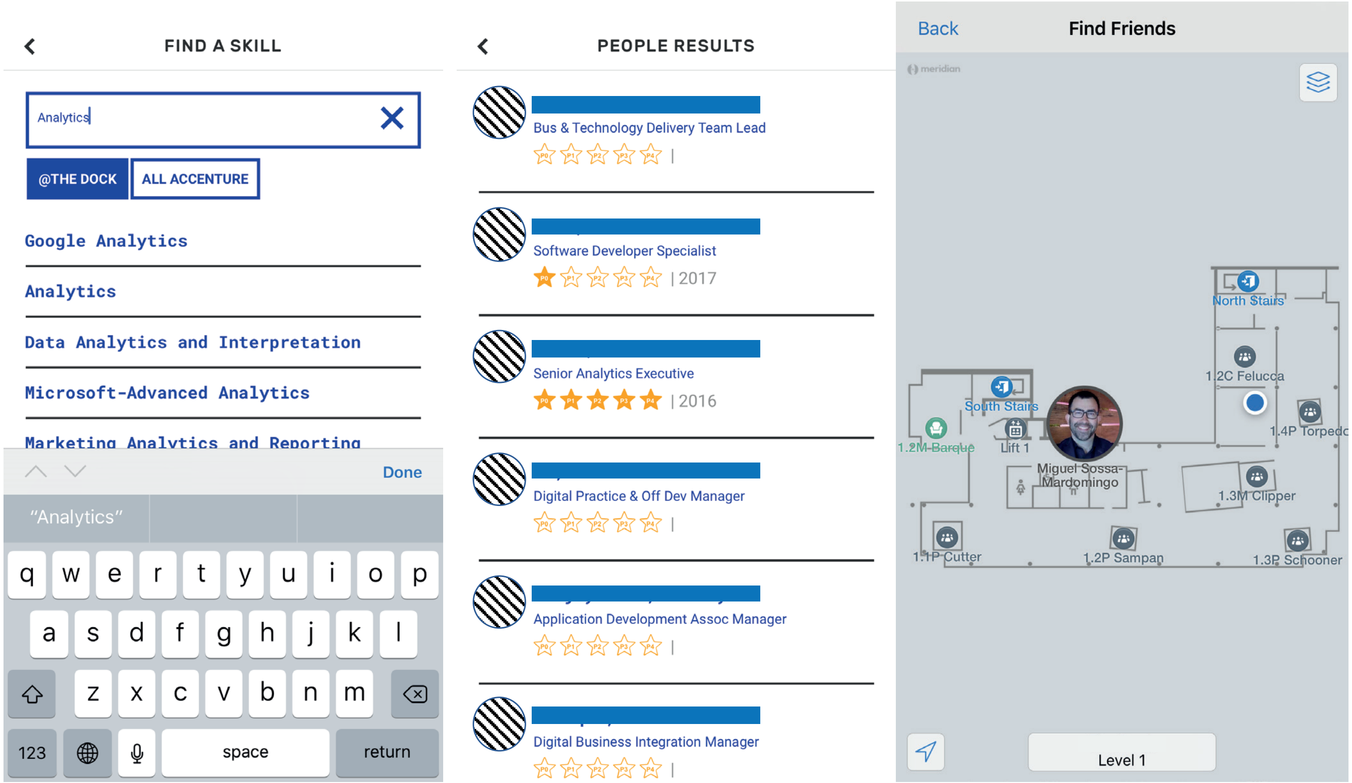


Figure 6 Find a skill mobile application
Source: Accenture (2017)

Find me a place to meet

As human resources department push the workforce towards increased collaboration, the workplace struggles to physically accommodate meetings in the short term. A leading technology company deployed a set of occupancy sensors that were located in individual meeting rooms. The data from the sensors was then integrated to a room booking system. This meant that planned versus actual attendance in meeting rooms could be compared for accuracy. In addition to this, live centre data meant the client was able to render live space usage, using a colour-coded system, on both an employee mobile application and public display screens. Spaces that were identified as available were then bookable immediately for teams to collaborate at short notice (see Figure 7).

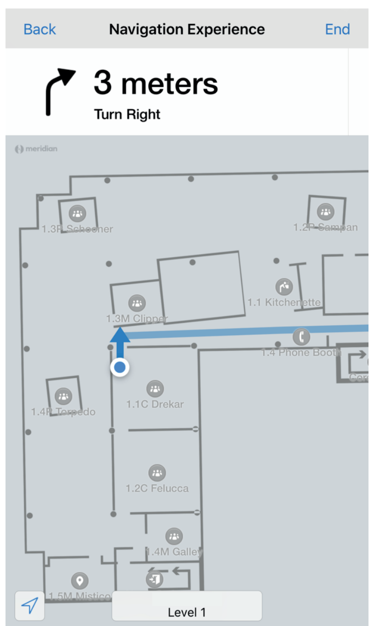


Figure 7 Find a place mobile app
Source: Accenture (2017)

This technology enabled 10 per cent increase in space utilisation,[31] reducing the demand for additional space from the users and realising an annual rental saving.

References

(1) Smith, A. (2016), 'Gig Work, Online Selling and Home Sharing', Pew Research center, available at http://www.pewinternet.org/2016/11/17/gig-work-online-selling-and-home-sharing/ (accessed 13th September, 2018).

(2) Unify (2014), 'New Ways of Working', Unify, Munich.

(3) Accenture (2013), 'Defining Success: 2013 Global Research Results', available at https://www.accenture.com/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/About-Accenture/PDF/1/Accenture-IWD-2013-Research-Deck-022013.pdf (accessed 13th September, 2018).

(4) Accenture (2018), 'Robotics Process Automation in Banking, Insurance & Capital Markets' available at https://www.accenture.com/us-en/insight-financial-services-robotic-process-automation (accessed 13th September, 2018); Everest Group/NASSCOM, (October 2015), 'Seizing The Robotic Process Automation (RPA) Market Opportunity', available at https://www2.everestgrp.com/Files/previews/EGR-2015-10-R-1609-preview.pdf (accessed 13th September, 2018).

(5) IDC (2016), *IDC FutureScape: Worldwide Analytics, Cognitive/AI, and Big Data 2017 Predictions,* IDC, Framingham, MA.

(6) Schoder, D. and Hassan, Q. F. (2018), *Internet of Things A to Z: Technologies and Applications*, John Wiley & Sons, Hoboken, NJ.

(7) Köhn, R. (2018), 'Konzerne verbünden sich gegen Hacker' ['Corporations Ally Themselves Against Hackers'], available at http://www.faz.net/aktuell/wirtschaft/diginomics/grosse-internationale-allianz-gegen-cyber-attacken-15451953-p2.html?printPagedArticle=true#pageIndex_1 (accessed 13th September, 2018).

(8) Nordrum, A. (2016), 'Popular Internet of Things Forecast of 50 Billion Devices by 2020 Is Outdated', available at https://spectrum.ieee.org/tech-talk/telecom/internet/popular-internet-of-things-forecast-of-50-billion-devices-by-2020-is-outdated (accessed 13th September, 2018).

(9) IDC (2016), *IDC FutureScape: Worldwide Wearables and Augmented Reality/Virtual Reality 2017 Predictions*, IDC, Framingham, MA.

(10) Statt, N. (2016), 'Boeing is using Google Glass to build airplanes', available at https://www.theverge.com/2016/7/14/12189574/boeing-google-glass-ar-building-airplane-parts (accessed 13th September, 2018).

(11) Accenture Strategy (November 2016), 'Workforce of the Future, 2016', available at https://www.accenture.com/us-en/insights/future-workforce-index (accessed 24th September, 2018).

(12) Meister, J. (2015), 'The Future Of Work: Airbnb CHRO Becomes Chief Employee Experience Officer', available at https://www.forbes.com/sites/jeannemeister/2015/07/21/the-future-of-work-airbnb-chro-becomes-chief-employee-experinece-officer/#7d651c642327 (accessed 13th September, 2018).

(13) Fitbit (2018), 'Press Release Details: "Fitbit Reports $571M Q4'17 and $1.616B FY'17 Revenue"', available at https://investor.fitbit.com/press/press-releases/press-release-details/2018/Fitbit-Reports-571M-Q417-and-1616B-FY17-Revenue/default.aspx (accessed 13th September, 2018).

(14) Investopedia (2013), 'The Causes And Costs Of Absenteeism In The Workplace', available at https://www.forbes.com/sites/investopedia/2013/07/10/the-causes-and-costs-of-absenteeism-in-the-workplace/#24f527d53eb6 (accessed 13th September, 2018).

(15) IWBI (2016) 'WELL', available at https://www.wellcertified.com (accessed 13th September, 2018)

(16) IWBI (2018), 'Making the case for better

buildings', available at https://www.wellcertified.com/en/articles/making-case-better-buildings (accessed 13th September, 2018).

(17) Matos, J. (2018), 'Measuring WELL: ASID post-occupancy analysis highlights the value of designing WELL', available at https://www.wellcertified.com/en/articles/measuring-well-asid-post-occupancy-analysis-highlights-value-designing-well (accessed 13th September, 2018).

(18) American Academy of Sleep Medicine (2009), 'Better Sleep Is Associated With Improved Academic Success', Science News, available at https://www.sciencedaily.com/releases/2009/06/090610091232.htm (accessed 13th September, 2018).

(19) Williams, H. (November 2017), 'Challenger bank Monzo clinches £71m and hits £280m valuation', Startups available at https://startups.co.uk/monzo-clinches-71m-and-hits-280m-valuation/ (accessed 13th September, 2018).

(20) Phillips (n.d.), 'The Edge', available at http://www.lighting.philips.co.uk/cases/cases/office/edge (accessed 13th September, 2018).

(21) CABE/BCO (2015), 'The Impact of Office Design on Business Performance', BCO, London, available at http://webarchive.nationalarchives.gov.uk/20110118111511/http:/www.cabe.org.uk/files/impact-office-design-full-research.pdf (accessed 13th September, 2018).

(22) Gensler (2016), 'The Gensler 2016 Workplace Survey', available at https://www.gensler.com/news/press-releases/us-workplace-survey-2016-findings (accessed 13th September, 2018).

(23) Stoddart, C. (2016), 'The Workplace Advantage: The Stoddart Review', Raconteur, London, available at http://workplaceunlimited.com/Stoddart%20Review%20Full%20Report.PDF (accessed 13th September, 2018).

(24) *Ibid*., note 15.

(25) Citrix (2016), 'Workplace Review', Citrix, Santa Clare, CA, available at https://www.citrix.com/content/dam/citrix/en_us/documents/case-study/a-redesigned-workplace-increases-productivity-enagement-and-space-utilzation.pdf (accessed 24th September, 2018).

(26) Accenture Digital (2017), 'Connected Facilities', from internal material accessible on client request.

(27) JLL (2018), 'The 3-30-300 calculator', available at http://www.us.jll.com/united-states/en-us/services/corporates/consulting/reduce-real-estate-costs (accessed 9th July, 2018).

(28) Ersules (2016), 'Engineering Report', Ersules, Dublin.

(29) Accenture Strategy (2016), 'Workplace Productivity Leakage Study', Accenture, Copenhagen. [AQ: is there a weblink for this report?]

(30) Sodexo (2016), 'Workplace Trends', available at http://sodexoinsights.com/wp-content/uploads/2016/03/Workplace%20Trends%202016%20Final.pdf (accessed 13th September, 2018).

(31) *Ibid*., note 28.

The challenges of retrofitting smart systems into existing buildings

Marson, M., Kinch, J., 2020

Published in the RICS Journal, December 2020

Introduction
As more of us uncover the benefits of using smart systems on our projects, the more we are finding complexity in how those systems are designed, installed, configured and procured. The challenges are even greater in existing buildings where legacy building systems need to be integrated. As all buildings are different, the mix of systems and how they need to speak and interact is also different. It has led to a landscape that is full of variance and therefore, complexity. Outdated skillsets, low abilities to make informed decisions and vendor over-promises have resulted in an industry that is cautious of innovation in existing buildings.

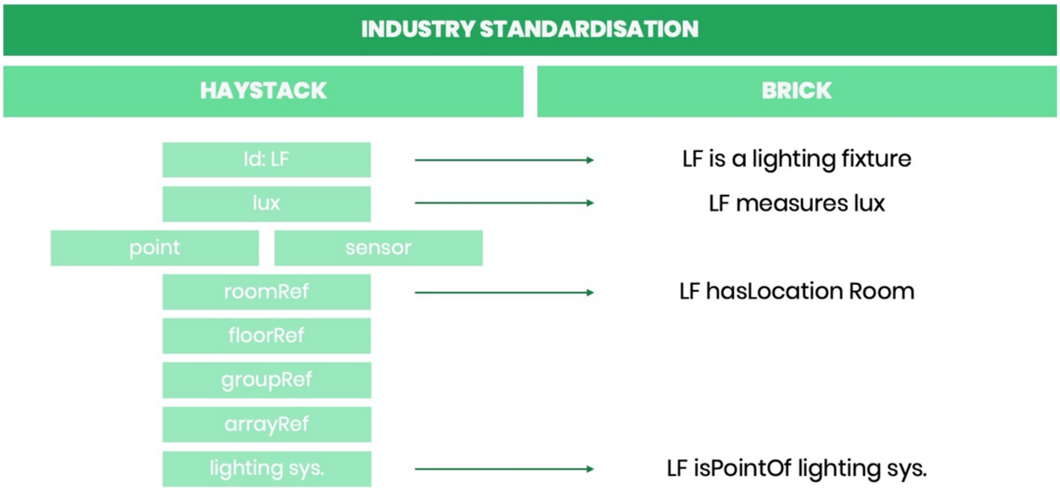
To overcome this and cultivate a culture of innovation and responsible technological exploration, we must first seek clarity on best practices for implementing technology within buildings. As an extension to this, we must then work to upskill and support all those maintaining, working with and using technology to ensure it delivers the value it promises.

New Standards for Compatibility
From a technical standards perspective, it is challenging to integrate and enable systems to meaningfully transfer information between each other. A significant hurdle facing building technologies is in how different systems are codified. It is common for different systems in a building to use different identification tagging formats for the same assets; a computer aided facilities management (CAFM) system might identify a light fitting as LGHT-001, while another system might identify it as LT-001.

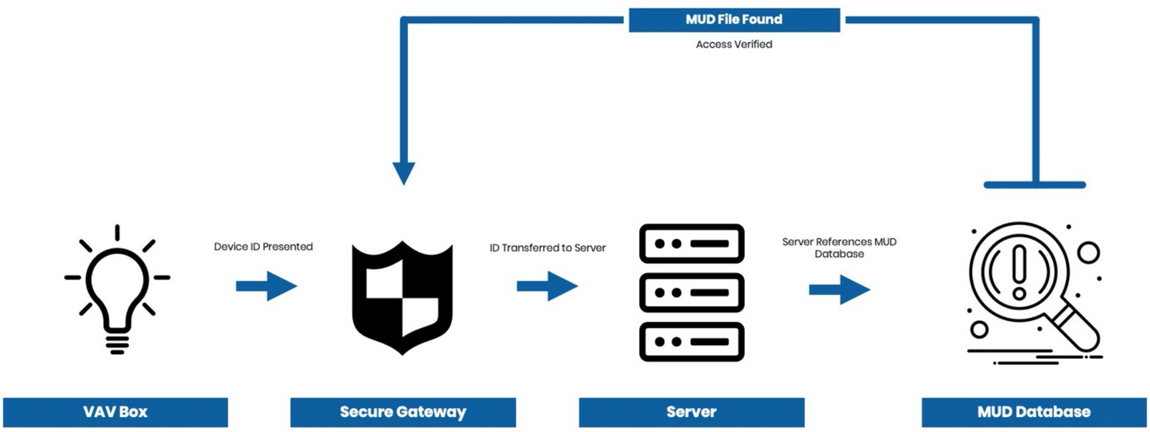
If these systems are to be integrated, without using the same tagging system, an additional layer of abstraction in the form of mapping, will be required. To reduce the technical burden in a retrofit, the systems have to undergo the time- and money-intensive process of updating one or both systems with the same ID formats. That same problem arises for new buildings where all systems may have been originally set up using the same asset ID tagging, but through ongoing maintenance and asset replacements the consistency of as tagging becomes diluted by miscellaneous naming of new assets not in keeping with the previous formatting standards.
In response to this ever-growing problem, an asset naming standard called Project Haystack (https://www.project-haystack.org) was developed. Haystack is open source and specifically designed to be a prebuilt standard that can be deployed at low cost to any building. Haystack, built originally of JavaScript Object Notation (JSON), establishes a clear format through which all building systems can be described, preventing deviation and inconsistency. Haystack is by no mean the only naming standard (Barker, J., 2019). Being open source means that it is in a strong

position to maintain relevance through ongoing community contributions as well as being free to use.

Brick Schema (https://brickschema.org) was developed as an extension to Haystack. It was acknowledged that system information is often viewed by people just as much as machines. As such, Brick Schema seeks to apply a layer of semantic description to make it easier for people to understand the relationship and hierarchy of various building systems.



Another key hurdle being tackled by new industry standardisation is that of device onboarding and verification. Buildings can often have thousands of digital systems and the process for onboarding and configuring these systems can often be laborious and expensive. In response to this and also in an effort to improve building security, a new standard called Manufacturer Usage Descriptions (MUD). MUD files can be preloaded onto a buildings IT/OT infrastructure, and these files then act as verification and configuration files for when new devices are connected to the building. Jumping to the lighting example again, as soon as the IoT enabled lighting fixture is installed, the building references the ID presented by the fixture against its MUD database to first verify the fixtures network permissions, and then to execute the correct configuration procedure, all automatically.



All put together Haystack, Brick Schema and MUD files each seek to resolve a key hurdle facing the greater integration and use of technology within buildings. Unfortunately, standards can only go so far to nudging building owners and operators towards better working practices. The obsolescence of technology after implementation remains unsolved despite these steps towards greater standardisation; the key to overcoming obsolescence lies not with new technological solutions but will well established stakeholder upskilling and engagement methods.

Case Study

> "One of my first smart buildings project was to take a client's existing building in the UK and reduce its energy consumption by 25% with no capital interventions. We did this by capturing the data from across the operations network and the Building Management System (BMS).
>
> Every 5 minutes we would store the live bacNET values from key plant and data centre equipment. We then transformed that data in an on-site SQL server to massage it into the format we needed and then uploaded it to an analytics package in the cloud. The analytics software was configured to understand the different types of machinery and how they worked with each other. It would analyse design intent against real-life operations and tweak BMS settings necessary. It could also see if the performance of assets of was degrading and predict their failure. Overall, the project reduced costs in energy and maintenance and was cashflow positive by month 9 of go-live.
>
> Back in 2014 we had to create the naming convention and data orchestration method from scratch – fortunately we now have standards to help do that heavy lifting." (Marson, 2020)

Skills

As smart systems become more the norm than the novel, we are going to see that building managers will need to pivot their skills to be more specialised in digital (Gurumurthy, 2019). There are an increasing number of anecdotes across the British construction industry where implementation mangers leave companies without their systems operations knowledge being fully handed over. Often, the buildings mangers that they are replaced with, do not have the skills to unpick, understand or modify the systems.

This is typical for bespoke integrations, where the system specialist can pick a personal preference of method. Implementing the aforementioned standards, building managers will be able to understand and update data flows, dashboards and automations in an informed and tactical way.

Skill such as basic coding, for rule writing, and database maintenance will become necessary to give operations staff the abilities they need to run a smart building. Leading facility management firms are already investing in these skills and capabilities (Biswas, 2019). As property developers use smart buildings technologies to compete for tenants and occupiers use the same technologies for COVID-19 compliance and talent attraction/retention, building managers will be called upon to modernise their skillsets and support their client's missions.

Conclusion

Until lots of the points discussed in this essay more mature solutions in the market, as professionals, we are going to have to challenge those that we collaborate with. The below three points are recommended to support the retrofitting of smart systems into existing buildings:

1. **Challenge vendors**

   Work with your construction and technology partners to ensure that you are getting technologies with the above-mentioned standards and people with the right skills. Today, there is a tendency to rely on traditional methods and systems and use value engineering as way to reduce risk in delivery by descoping critical integrations.

2. **Appoint an MSI**

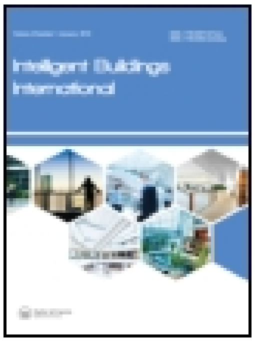
   A Master Systems Integrator combines knowledge from the world of controls and digital to create systems that fulfil your brief. They have the necessary skills to create a range of integrations to prepare data for ingestion at the platform.

3. **Keep learning**

   There are now course providers like digitalbuildingsboot.camp that offer easy to digest courses designed for built environmental professionals to become conversant in digital. Being able to understand the key terms and concepts will ensure that you are able to make informed purchasing and implementation decisions.

References

Barker, J., Tacking the Tower of Babel, British Land, London, 2019.
Biswas, A., Smart for Operations, WSP, London, 2019.
Gurumurthy, R., Pivoting to Digital Maturity, Deloitte LLP, London, 2019.
Marson, M., Client Case Study Interview, 2020.



Intelligent Buildings International

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tibi20

The human connection to an intelligent building

M. Marson & J. McAllister

To cite this article: M. Marson & J. McAllister (2021): The human connection to an intelligent building, Intelligent Buildings International

To link to this article: https://doi.org/10.1080/17508975.2021.1872480

Intelligent Buildings International
https://doi.org/10.1080/17508975.2021.1872480

Taylor & Francis
Taylor & Francis Group

Check for updates

The human connection to an intelligent building

M. Marson and J. McAllister

Arcadis Ltd, London, United Kingdom of Great Britain and Northern Ireland

ABSTRACT
Intelligent buildings are often concerned with the efficiencies of energy, space and health and wellbeing. The pursuit of technological prowess and measurable outcomes has led to a design epoch devoid of meaningful human connection to an intelligent building and the services that it delivers. This paper presents an application of design thinking to the built environment and assessment of the human meaning that it can influence. Furthermore, a set of mature and emerging technologies are discussed with some demonstrable interaction outcomes. The paper concludes with a critical analysis on the nuances that the processes and technology are able to craft – a magic that has seldom been achieved by existing intelligent buildings.

ARTICLE HISTORY
Received 5 October 2020
Accepted 4 January 2021

KEYWORDS
Design; human; design thinking; mobile applications; UX; experience; interaction

Introduction

As the demand for intelligent buildings increases across the market (Memoori 2019), so does the need for human interaction with supplied digital services. The emergence of fourth industrial revolution technologies, such as Internet of Things (IoT) devices and platforms, solutions for big data ingestion and manipulation, sensory stimulation and more, has created a culture of technology 'one-upmanship' across the global property industry (Okraglik 2019). Technology itself becomes the focus of intelligent building implementations rather than their outcomes or the experience that it crafts.

JLL estimates that for most corporate property, a business's cost base is 90% people, 9% rent and 1% energy (Mason 2019). It stands that neglecting to have a resolute focus on the human experience, that is delivered through intelligent buildings, is to discount the vast majority of addressable value.

In instances where token human/machine interaction (HMI) layers are utilised by buildings, they often miss the mark against user expectation (Broussard 2019). An example of this would be reception sign-in screens that require the visitor to input a lot of information that a human receptionist would be able to do without explicit questioning. A user expectation is a set of unspoken or unwritten requirements. Those involved in the design, delivery and operation of the built environment are yet to employ the techniques and tools of technology specialists to close the expectation gap.

Combining this sentiment with a macro-trend towards a fatigue with poor experience design, an eminent digital consultancy captures …

> We're seeing a dramatic escalation in the rate at which people disconnect, unsubscribe and opt out to stem the barrage of content and messages that clutter daily life. As consumers, we've come to realize that it's no longer simply a lifestyle choice, but a serious mental health issue. As we put up more barriers between ourselves and

CONTACT M. Marson matthewmarson@gmail.com

digital technologies, organizations must learn how to offer value to users who crave quiet in a noisy world. (Fjord 2019)

As a result of a growing negative sentiment towards intelligent buildings technology (Okraglik 2019), it is imperative that designers of the built environment now consider how digital experiences alter our interaction with a space, and design accordingly. 'The values users seek from products, services and organizations are shifting. Where once we celebrated novelty, excitement and instant gratification, we now reject organizations that shout to get our attention' (Fjord 2019).

By acknowledging the human connection to buildings in the design of technology, it will be possible to address the value locked in JLL's 90% cost-base. More importantly, our enjoyment of spaces on a human level will increase.

Through applied research and implementation on scores of international design projects, this paper presents a set of adapted methods (ways of designing) and solutions to ensure a meaningful human connection to fourth industrial revolution technologies in the context of an intelligent building.

The processes to designing a human connection

To understand our connection to the built environment, we must first understand our approach to design and introduce the role of the designer who will nurture from concept to creation. It is a role that relies on collaboration, intuition and holds strength in numbers. One of the most basic but integral skills is the ability to hold an idea up to your peers, let it undergo a process of scrutiny and forego any idea that does not pass the test. This is how designers are able to move past what they assume to be best and produce innovative designs with the greatest value to users.

Experience design is an integral part of human-centered design and aims to understand users and their interactions between systems, services, spaces and a multitude of other internal or external factors that could impact their experience (Lewrick et al. 2018).

Experience design considers products, services or systems that can be applied to the entire project and tries to ensure that, in the early stages, nothing is over-engineered (Hazzenzahl 2008). The design should always follow the ethos of 'no idea is a bad idea' – this philosophy prevents ideas being prematurely discounted and provide genuine benefit. Each product, service or system can be examined through a human lens to understand how it is applicable to the core values of an individual. Designers often ask how a strategy or design intervention can help a user to become more efficient for some of the more menial tasks throughout the day. They seek to understand how the design can provide a user with more fun and entertainment. Additionally, designers seek to understand how their work can support a user to make informed decisions. In essence, each technology, system or service should provide value. However, value to one is not value to all.

Understanding the views of a community or demographic through detailed ethnographic research and focusing it into an offering that works for each user is often the answer (Lewrick et al. 2018). Getting 'under the skin' of another allows the designer to move past the perceived value and construct a foundation on which tangible value is built, or at least, perceived (Hasso Plattner Institute of Design 2020; Design Council 2020).

To document their process and key decisions process, a designer creates a collection of documentation. Vision documents (1), personas (2), user journeys (3), use case playbook (4) and a backlog (5) are created to visualise the experience and support the foundational aspects of the design.

Vision document

A vision document is a highly graphical document that captures the essence of the project by describing the value and drivers that shape decisions. It consists of a set of aims and objectives, key performance indicators and methods to achieve the defined value.

A vision document grounds a project and acts as the foundation on which the other works can be built upon. Without it, the project risks becoming aimless in direction and muddied in delivery.

Personas

User personas capture a selection of users and describe what human experiences are important to them. The set of personas should be inclusive of all demographics expected to interact with the building or space.

They allow stakeholders to engage with the project to find a personal connection to a set of digital solutions and are important in the collection of feedback on concepts created for the project.

User journeys

A user journey showcases how a persona lives a day, week or even a year in their space. It describes what and how they interact with a variety of different technologies, systems and services and may track the events, emotions, touch-points and paint-points captured within each interaction.

In order to understand what must be included in a building or space, we must first understand the people within it and how they may or may not interact. User journeys help to delve further into the understanding of the user and what will provide the project with the greatest value.

Use case playbook

This type of document shows a set of example functionality and technologies applied to the project including digital and physical requirements, system dependencies, integration requirements and perceived value related to the project.

The playbook can be used as a starting point in order to derive the systems and additional requirements needed for implementation and can supply clients with a 'shopping list' of digital solutions or technologies to choose from.

Backlog

A backlog is a living document that can describe functional and non-functional requirements for a product or service and provide a means of prioritisation and dissemination of ownership.

Vital to the success of many products, especially within software development and agile workflows, a backlog provides the single song sheet against which a team can align. The outputs of continuous ideation can be held within a document like this with it never truly being finished until the end of a product lifecycle.

Once created, these documents allow the designer to test their theories. Although built from an understanding of who our users are, there is always a need to test. Only through thorough testing can we truly validate the works and provide a case for change (Hasso Plattner Institute of Design 2020; Design Council 2020). This testing must be on the users that are impacted by the application of the technologies, products, systems or services. The users who will interact with the deliverables on a daily basis and those who stand to gain something from them. This scrutiny and feedback will validate the experience as a whole and ensure the solution meets the expectation of the users.

As our needs change so frequently (Fjord 2019), it is essential to note that the process described above is not static. The results and feedback produced today, even for the same demographic will be out of kilter to those collected in 12 months. A continuous loop of development and feedback is vital to success within experience design and one which can seem arduous to those who cannot see its true initial potential.

To properly comprehend the experiential value, fiscal remuneration and return must be pushed aside. Not forgotten, but paused until the experiential benefit has been assessed. This is something most organisations are not yet accustomed to and is a difficult hurdle to overcome. Loss-leading implementations of products and services usually produce some opportunity to market a development and encourage a buzz around community, health & wellbeing and a multitude of other excellent marketing opportunities (Sheppard et al. 2018). They also encourage an entirely intangible benefit – enjoyment. Seemingly overlooked, the factor of enjoyment can make or break our interaction with a service, system or building entirely. Combined with our often consumerist, quick-to-discard, human interaction with technology, enjoyment can be the linchpin for success (Hassenzahl 2003).

Throughout the design of the human connection to an intelligent building, an iterative methodology will benefit the designer to ensure that the design will evolve in a natural and progressive manner (Lewrick et al. 2018). Much like other areas of design, it is never truly finished, and a continuous assessment loop is often employed to sense check design works. It also allows for a collection of designers to input and create something collaboratively that holds the best of each of them.

The concept of human-centred design was first being documented in the early 1990s (Lyonnais 2017). There are instances where the expectations of a building's user is not met by their designers. A known cause for this is the difference between the user's assumed and actual need. A conversation with those interacting with the digital services of an intelligent building is pivotal to success (Design Council 2020).

Growing dissatisfaction with intelligent building technologies has pushed user experience from an afterthought to the forefront of design. It is often impossible to tell when an experience, as a user, has been carefully considered as components work precisely as intended. However, it is glaringly apparent when things have gone wrong (Hollis 2019). For a project in London, both tenant and landlord intended a mobile application experience to be prominent in their designs. By not collaborating, the building's users now need two different mobile applications – one for the foyer security and another to book a desk. This is a cumbersome experience that could be have been avoided with adequate coordination and the employment of human-centred design.

To stay current and relevant, technology vendors have been tackling human machine interaction (HMI) design methods with which users are not happy. There is a perception that too much functionality and general 'noise' thrown at users alongside commercial venture seek our attention, it has become necessary to tackle the issue of digital attention seeking from our personal devices. The Light Phone 2 (the light phone inc. 2020) stripped the mobile phone back to basics by providing users with only the most valuable core functionality; the ability to call, send a text, set an alarm or access a calculator. The same approach is gaining momentum within the built environment to ensure that the underlying infrastructure of a building stands up to scrutiny and can support additional digital solutions, whilst delivering a high-quality set of basic services. Designers are starting to understand that some technologies are superfluous and what is actually valuable is to help users on a far more foundational level.

Design Thinking is a set of methods that are now emerging in the design process for the human interaction of an intelligent building. Figures 3–6 demonstrate some design outputs that use Design Thinking when considering human interactions. Design Council's Double Diamond (Figure 1) and the Stanford d.school model (Hasso Plattner Institute of Design 2020; Design Council 2020) are exemplary methodologies that have helped to understand, explore, model, test and implement solutions across any industry.

The process is highly collaborative and preaches a 'Show me, don't tell me' ethos allowing for decisions to be made with complete comprehension of what the end goal will be (Hasso Plattner Institute of Design 2020).

Both methodologies start with the same basic principle of undertaking due diligence towards the users in question. Rather than assuming that those within the design process are in tune with the users, time is spent trying to empathise and assimilate with those affected.

In the next stage, a clear and concise definition of the problem at hand can be formed to support the next steps in the design. Much like most pragmatic problem-solving methodologies, Stanford's

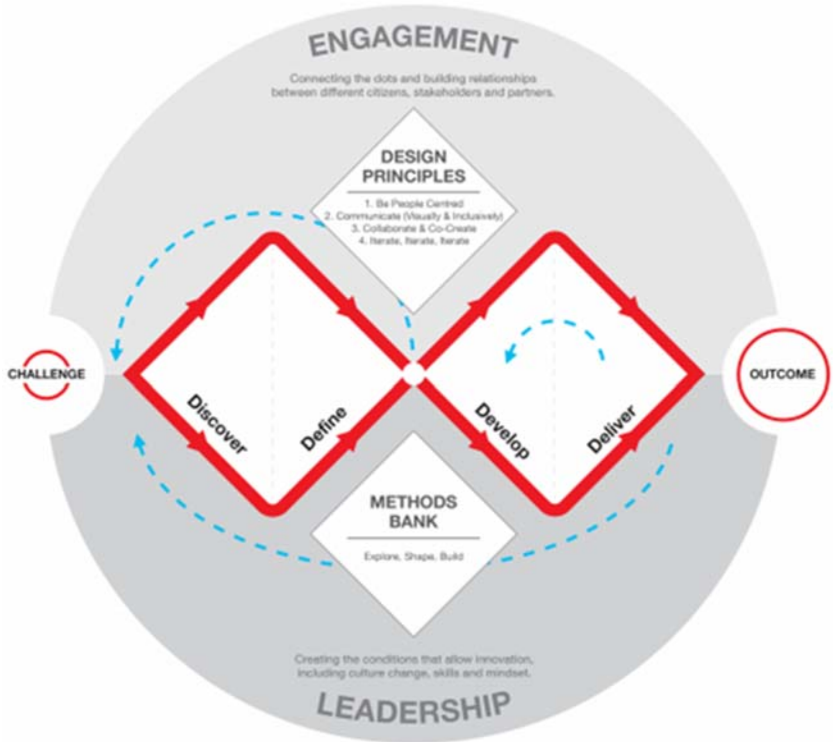


Figure 1. Double-diamond Design Thinking process (Design Council 2020).

d.school and the Design Councils Double Diamond both go off to expand the problem and list possible solutions without trying to over examine, enabling them to push beyond the obvious (Hasso Plattner Institute of Design 2020; Design Council 2020).

The last few steps create and test the solutions against those that have been designed for in order to collect as much feedback as possible to refine the solution.

Retail companies, with their focus and shift into eCommerce, have often failed to create an engaging physical offering. Fierce competition has led to an online capability war (Fjord 2019).

Nike's flagship New York City store is an example of matching an organisation's physical retail offering with their e-commerce. Nike understand why baskets are abandoned online but knew little about the same phenomena in their physical space. The company was able to gain insight from their online capability to understand exactly what customers wanted in their physical stores and how they interacted with the space and products. Using the double-diamond Design Thinking methodology, the designers were able to unpack the problem and match to suitable solutions with the emphasis being firmly focused on user outcomes. To capture that data, the company installed a set of sensors to gain similar insights to those gained online. Footfall, pedestrian flow, item abandonment and product engagement could be tracked against a user's connection to the store and the overall human experience. The perceived dissatisfaction is noted through the actions of the shopper. These actions that were previously subtle, are now clear with the sensoring technology. The data has allowed Nike to make informed decisions on their retail space (Fjord 2019).

Primarily, it should be understood that personalising a technology or service does not mean it cannot affect a significant percentage of the user population. There are often themes that run across all user demographics of the building which have intrinsic cross-over and help to tie disparate services together. Personalisation should only encourage designers to delve deeper into what may produce a more refined design result, rather than one they do not hold in such high regard (Fjord 2017).

Quality must also be another trait that a designer must strive for, rather than plugging in as many services as they possibly can in the pursuit of 'one-size-fits-all'. Having too many services leads to confusion for a user and subsequent dissatisfaction. It is essential for the designer to control the offering and define which services, systems or products provide the most value (Hollis 2019).

Furthermore, it is imperative to design for accessibility. It is important to consider the demographics that could be under-represented and, therefore, enhance the design to account for their perspective. For example, it may be a building with only a small population of disabled users but providing some bespoke services for this user type may make a bigger impact than something for the wider population (Stanley 2018).

As another consideration, the majority of assumptions must be taken out of the way designers design and operate. The process of assuming an outcome does disservice to the process of design and discovery and should be avoided at all costs. Designers must ensure they investigate and spend the time to discover what the correct direction for the design should be – they should not proceed with an understanding of a point of view that has not been properly uncovered.

As mentioned previously, avoiding an 'over-engineered' approach to design is the difference between uncovering value or not. Having an outcome already set leads to driving the design into a direction it may not have naturally gone in. This is all in an effort to ensure we properly assimilate and empathise with the eventual user of the space and design for their own needs, rather than our own.

Lastly, it cannot be stressed enough how important it is that user experience design is done as a collaborative effort (Hollis 2019). A team is essential to balancing the final output. The same way as the design does not revolve around a single person – a single person cannot design for the collective. Diversity in a design team creates diversity in results and something that can bring a design from successful, to industry-leading (Rock and Grant 2016).

Elements of human interaction

The process for designing how a human connects with an intelligent building follows the above process and methodologies and results in the creation of the aforementioned artefacts. The technical elements, however, are wide ranging and varied. Below are brief analyses of the most prevalent technologies to be used to create a human connection in our spaces. Figure 2 sets out an analysis of how the intelligent buildings technologies are able to provide different levels of interaction and bespoke experiences. Using design thinking to understand the outcome, the below analysis acts as guidance to select the correct technological interfaces to deliver a meaningful interaction to the building.

Mobile App

Mobile applications are used within intelligent buildings as a way to provide personalised content and interaction with operational technologies. Services or experiences that work well on mobile applications are typically personalised and private.

Mobile applications created specifically for a development or building are growing in popularity (Okraglik 2019). For multi-tenanted buildings, they are usually employed to create a culture between tenants. In addition, they usually tackle access control, lighting and temperature control as well as some transport information. A notice board is often the central functionality. Most developers are commissioning these apps due to vogue (Okraglik 2019) rather than how meaningful an experience they deliver.

Technical teams are often those selected to deliver the mobile application of a building. As a result, functionality is transactional and practical. The opportunity to humanise and increase meaningfulness is often lost. Figure 3 shows a wireframe of an application with functionality that helps a user find space but connects with them around the desire or need for that space.

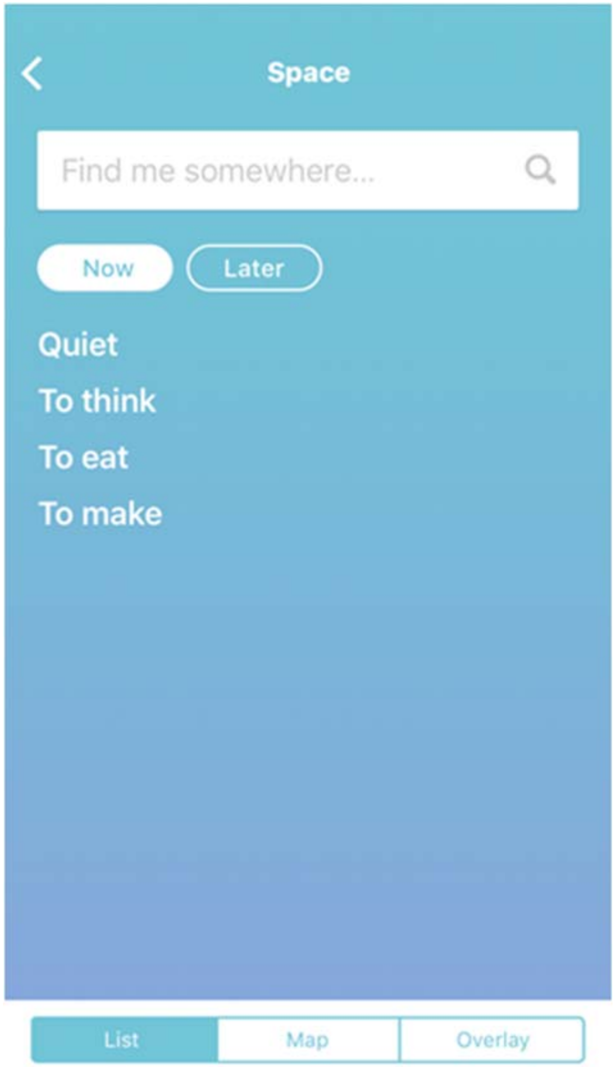


Figure 2. An analysis of how Intelligent Buildings technologies provide different levels of interaction and bespoke experiences.

Mobile applications are an opportunity for designers to deliver a living service that meets emotional as well as practical needs. Most measure the success of a mobile application by the number of downloads (Okraglik 2019). Instead, user satisfaction or repeat visits give a better indication of the quality of application delivered. Central data infrastructure will allow the experience to be delivered in coherence with and beyond the device through screens, dashboards and other interaction methods.

Mobile applications allow for deep level of interrogation/interaction and for a range of personalisation potentials for the user.

Screens

The amount of screens in our buildings are increasing (Cyviz 2018). The display of functional and creative content is giving designers the opportunity to explore how variable visual displays change the interaction a human has with a space. Fjord, the global design agency, use interaction design to create in-building experiences that feel like living services. Beyond changing posters, interaction designs are focused on how physical placements and gestures change a digital display (Fjord 2017). Figure 4 demonstrates how designers could re-size and change interaction mode with screens on the basis of proximity. Far away, attractor mode (Figure 5) shows variable content that piques interest to come closer. At a mid-range, the human is able to gesture control (Figure 6) through control and disrupt the display's elements. Up-close (Figure 7) the interaction comes to a comfortable height and accepts complex touch interactions.

Large format and interactive screens give designers the opportunity to create experiences that cannot be delivered on a mobile device. Experiences that would benefit from group interaction or public observation give light to ludic events. These could be expressed through celebration (such as a birthday celebration), connection creations (such as a map of skills, places to visit or live space utilisation) and competitive events (such as floor-level energy consumption or points collection). Building data, imagery and strong visual language allow for a successful sentiment to be felt by the user.

Screens allow the designer to achieve a passive interaction and a generic experience.

Dashboards

Within intelligent buildings, dashboards are used to visualise the vast amounts of data that are collected to make it legible to a human. These can be leveraged for operations in order to make informed decisions through the building data being clearly displayed (Iconics 2020). Operations teams can be shown only what is most relevant to them and eliminate arduous manual filtering of extremely large data sets.

Graphics (in terms of user interface) can often play an important part in how dashboards are created and used. With the impending requirement of carbon neutrality within the built environment, it is of great value to be able to show others how you are performing and use this as a method to encourage potential tenancy and build trust from the public (British Land 2020).

There are many tools which are designed to bring us closer to information that is valuable to us. Power BI (Microsoft 2020) allows those with little to no experience of data management or manipulation to produce powerful dashboards that showcase important trends within data. Without easy-to-use tools such as this, operators are beholden to another form of specialist to deliver the outcomes needed.

Dashboards allow the designer to provide an active level of interaction with a highly bespoke and customisable experience.

Biometrics

Humans have unique physical and behavioural traits that help to distinguish one another. These can be genetic such as facial shape, fingerprints and iris patterns or other means of distinction such as tattoos and embedded chips (Bioteq 2020). Each distinctive feature adds variety, and it is this variety that can be leveraged as a means of identification.

Commercial usage of biometrics has been widespread for many years with a variety of mobile devices employing it for minor security-based tasks such as unlocking the device, to becoming a method of authenticating a payment using technologies such as Apple Pay (Apple 2020).

The first use of fingerprint scanners for mobile devices was Toshiba in 2004 with the GI100 device leveraging the technology for authentication and fingerprint speed dialling (Jayaditya 2020).

Since then, the world of biometric authentication and security-access has meant the technology has come on dramatically to reduce the error rate to an acceptable level as a means of authenticating a physical transaction.

Facial recognition is also a popular biometric-based technology that has seen success by integrating it into security systems for buildings and city-scapes to improve a user's experience by providing a time saving benefit. Developments such as King's Cross have tried deploying facial recognition

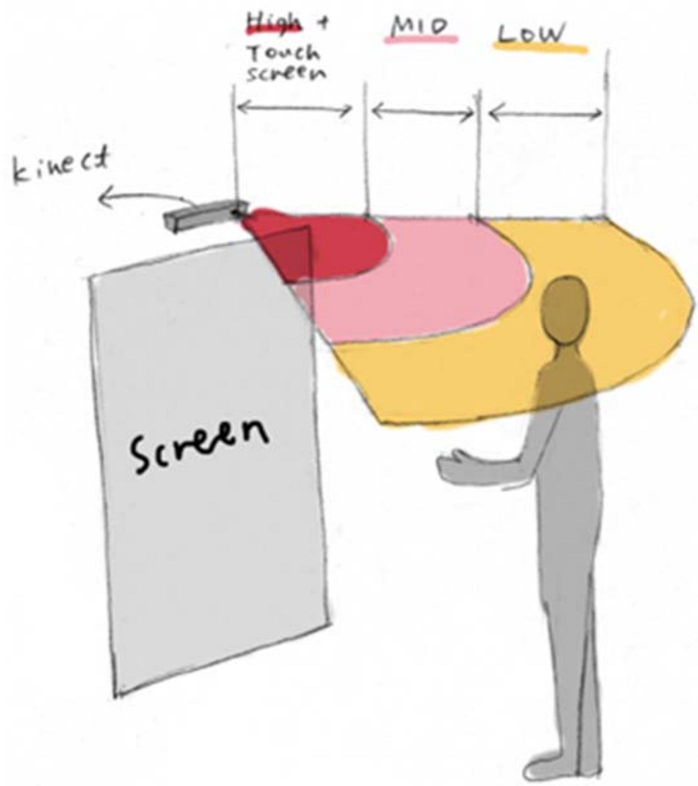


Figure 3. Application wireframe (Fjord 2016).

systems to improve the experience of the user of the site with an aim to improve the safety of all those across the development (King's Cross 2019).

However, the trend to disconnect with those technologies around us and the aspiration to feel a little more 'off-the-grid' do not work hand-in-hand with biometric technologies, especially facial recognition. Many of these deployments face heated ethical debates as to whether it is socially acceptable to breach an individual's privacy and to that extent, how privacy and the policies surrounding that of data collection and management should be created and handled (Mikkelson, Soller, and Strandell-Jansson 2020). The advent of the General Data Protection Regulation (GDPR) in

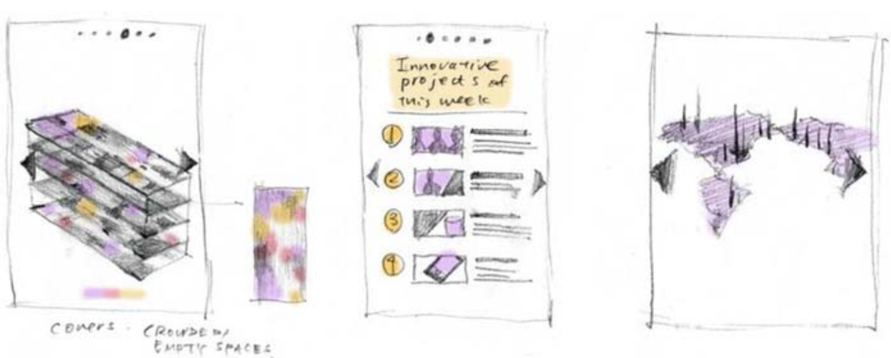


Figure 4. Distance-based interaction adaptation (Fjord 2016).

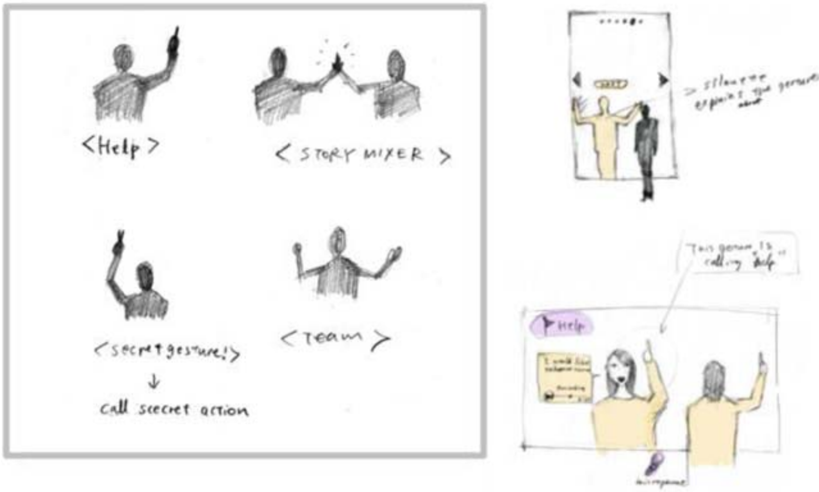


Figure 5. Attractor Mode Development Sketches (Fjord 2016).

May 2018 gave these technologies food for thought (Fjord 2019) in order to market the technologies as something not to be frowned upon, but rather a means to keep people safe, secure and happy (Rossow 2018).

Biometrics allow the designer to deliver active interactions with a semi-bespoke experience.

Implantables

Wearable technologies such as the Apple Watch and Fitbit range have shown their worth by helping us understand more about how we eat, sleep, exercise and even help us remember to pick up the milk on the way home (Apple 2020; Fitbit 2020). However, the value of implantable technology has now become too big to ignore, and this type of technology is proving useful across a variety of market sectors.

Smart tattoos developed by Harvard and MIT researchers are capable of changing colour depending on specific health conditions, for example, if a diabetic's blood sugar is low. The advent of 'implantables' within the medical sector is not new, with pacemakers and Implantable Cardioverter-Defibrillators being well established (Aquilina 2006). However, with the IoT generation networking any device they can get their hands on, it was not going to be long before newer use cases emerged with each one providing a benefit to even the most niche of user demographics.

Some more commercialised uses of implantable technology are in miniature RFID transponders encased in silicate glass embedded under the skin on a person's body, usually the wrist or hand. The

Figure 6. Gesture Mode Development Sketches (Fjord 2016).

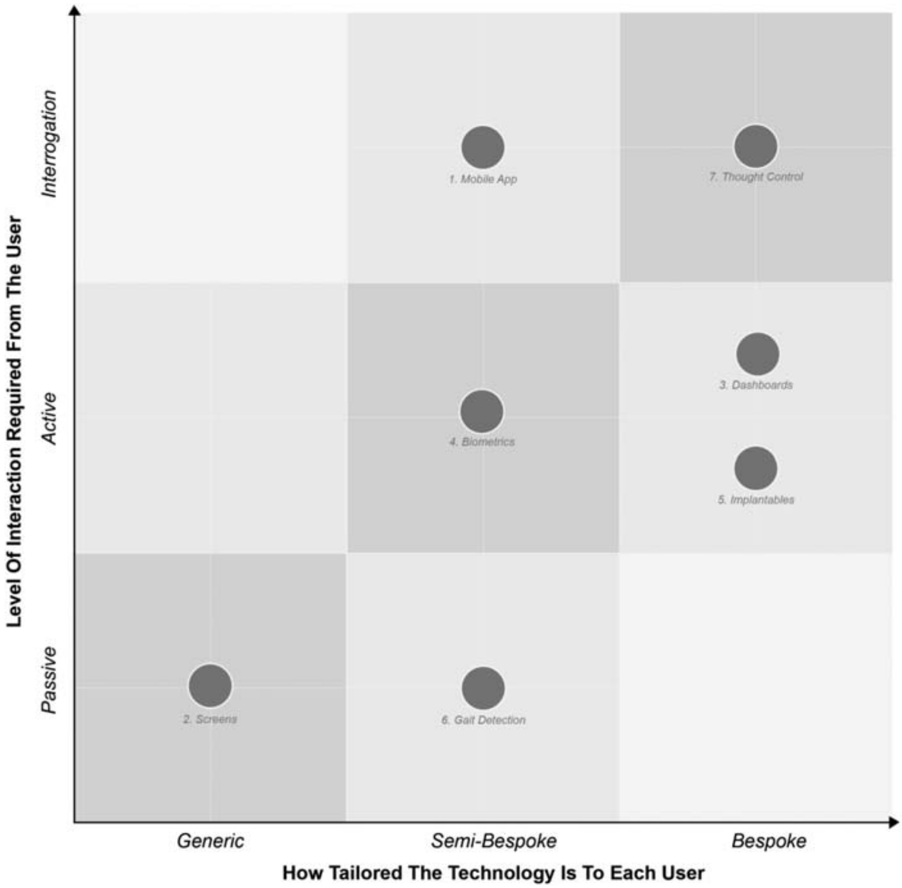


Figure 7. Up-close Interaction Development Sketches (Fjord 2016).

implantable stores a unique ID number that can be linked to an external database of information such as personal ID, medical history, contact information, payment information or merely a digital credential to unlock your front door. The ethical debate of feeling tagged and numbered is felt by many individuals, is driving this trend to become more underground and creating the cult of the man-machine (Savage 2018). It cannot be denied that this arrangement of technology can provide users with a number of experiential benefits akin to those gained by the use of a mobile device.

Implantable technologies have grown out of either a necessity to become heavily intertwined with our technology-based world or out of our inherent need to simplify the spaces around us. Unfortunately, these technologies are still not mature enough to identify which is the driver and therefore, how long of a run it will get. If the technology can prove its value in replacing the need to carry access cards, other methods of payment or authenticate who we are, then it may become more heavily adopted.

Implantables allow the designer to deliver active interactions with highly-bespoke experiences.

Gait identification

A face is a very distinctive feature for a person. In many countries, cultures and situations, it is not always possible to show your face, or present it in an easy way for a camera to capture (Ayonix 2020).

Gait identification uses body shape and the way that people walk to identify them without the need to show a face. This is a reliable method of user identification in the majority of scenarios.

Deployed in the cities of Beijing and Shanghai, China, it is being used to drive the concept of data-driven surveillance (Cuthbertson 2017). Although approximately 94% accurate and, therefore, only viable for commercial use, it fills the gaps left by facial recognition or iris detection methods. With far less of the population realising that we can be recognised by our gait, it gives fewer places for anonymity and provides property developers and intelligent buildings designers considerations for what 'biometric access' means to a building.

Gait-detection technology has the potential to create semi-bespoke experience despite its passive level of interation.

Thought control

As cognitive-based technologies become more widely accepted, it would be expected that simple controls through to devices will be done so using mind-reading type technologies.

Facebook has been developing this type of HMI method (Facebook 2020), and has recently published the results of their recent study to decode speech directly from brain activity (Facebook 2020). This could mean the future of communication with our devices may become entirely non-verbal and non-physical, with this extending to the control of a plethora of equipment. The refinement of this technology could take years, but could revolutionise the way people interact with spaces, especially those affected by physical impediments (Goldman 2017).

Thought control technologies have the greatest potential for designers to craft high interaction and highly bespoke experiences in intelligent buildings.

Critical analysis

Understanding the ethos of design thinking and the potential afforded to us by innovative solutions developed to help us to engage with technology is a positive start. It would be unrealistic to assume that a user's connection to intelligent buildings would be a simple task and this is heavily reflected by the amount of user experience agencies that are trying to tackle this issue (Memoori 2019). Knowing which technologies to use and when to use them is a balancing act which requires an experienced set of designers, effective documentation and complete comprehension of the problem aiming to be solved. With a rapidly growing smart buildings market saturated with vendors whom all claim to have robust solutions, an understanding of those solutions and the vendors that provide them, has become even more valuable.

Design thinking is only the methodology that acts as a foundational set of practices/tools to facilitate a building's design process. It is the effective application of these design principles that delivers a design and its potential users' value.

Currently, developers and user experience designers expect a user to turn up to a building with personal hardware in order to interact with the building. Expectations are running high from the promise of intelligent buildings (Okraglik 2019); with the core HMI not being provided, it is difficult to produce a space that has a well-rounded, properly considered and deeply ingrained experience design component. Technology can be fun and functional simultaneously, and like people, buildings have personalities – quirks and nuances heavily ingrained within the design. This 'spirit' must be reflected in the digital services selected for each building by matching the solution to the problem and not implementing technology because it has an assumed value to add.

A user of a building should be able to look up from their phones and enjoy the building. Spend time appreciating the ambience and subtle benefits of the technologies. Technology should help us to speed up outcomes, eliminate arduous processes, find the people and things we need with ease and give us enhanced control. Mobile applications, however, are starting to remove that control as presets remove our ability to personalise (Hollis 2019). The continuous feedback loop built into design thinking processes will help designers to address where changes must be made and if a technology implementation is worthwhile.

In conclusion, despite having robust tried and tested technologies and some compelling emerging technologies, a meaningful human connection is still not prevalent in the design of intelligent buildings. Design thinking methodologies applied to the built environment are gaining popularity, but there is still lots of progress required for us to love our digital services as we do our favourite spaces.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributor

Matthew Marson MEng CEng FIMechE FRSA UK Sector Director for Manufacturing & Technology at Arcadis as well as heading up the Arcadis Buildings Design Practice. He focuses on designing and delivering digital real estate transformation and human-centred Internet of Things (IoT) technologies within the built environment. Matthew founded WSP's Smart Places practice, was elected as a Fellow of the RSA in 2017 and named as the Institution of Mechanical Engineers Young Visionary 2016/2017 for his work in creating The World's Most Connected Building. Matthew sits on the CIBSE's Intelligent Buildings Group and is a keynote speaker at international industry events.

J. McAllister BA (Hons) is a Senior Intelligent Buildings Consultant with a focus on UX and human interaction in the built environment.

ORCID

M. Marson http://orcid.org/0000-0002-0925-0685

References

Apple. 2020. Apple Inc. Document Accessed Online: https://www.apple.com/uk/apple-pay/.

Apple. 2020. Apple Inc. Document Accessed Online: https://www.apple.com/uk/watch/?afid=p238%7CsjHUjLmSy-dc_mtid_20925xua42643_pcrid_465982635782_pgrid_112714367201_&cid=wwa-uk-kwgo-watch–slid–productid–.

Aquilina, O. 2006. *A Brief History of Cardiac Pacing*. National Center for Biometric Information. Document Accessed Online: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3232561/.

Ayonix. 2020. Ayonix Corporation. Document Accessed Online: https://ayonix.com/.

Bioteq. 2020. Bioteq Limited. Document Accessed Online: https://www.bioteq.co.uk/.

British Land. 2020. The British Land Company PLC. Document Accessed Online: https://www.britishland.com/.

Broussard, M. 2019. *Artificial Unintelligence*. London: MIT Press.

Cuthbertson, A. 2017. *China Rolls Out Surveillance System to Identify People by Their Body Shape and Walk*. Independent. Document Accessed Online: https://www.independent.co.uk/news/world/asia/china-surveillance-facial-recognition-body-walk-technology-watrix-privacy-cctv-a8622156.html.

Cyviz. 2018. *Shaping Innovation Spaces*. Oslo: Cyviz.

Design Council 2020. Design Council. Document Accessed Online: https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond.

Fitbit. 2020. Fitbit Inc. Document Accessed Online: https://www.fitbit.com/uk/home.

Fjord. 2016. *The Dock*. London: Accenture.

Fjord. 2017. *Living Services*. London: Accenture.

Fjord. 2019. *Trends 2019*. London: Accenture.

Goldman, B. 2017. *Brain-Computer Interface Advance Allows Fast, Accurate Typing by People With Paralysis*. Stanford Medicine. Document Accessed Online: https://med.stanford.edu/news/all-news/2017/02/brain-computer-interface-allows-fast-accurate-typing-by-people-with-paralysis.html.

Hassenzahl, M. 2003. "The thing and I: understanding the relationship between user and product." In *Funology*. 2, 301–313. New York: Springer.

Hasso Plattner Institute of Design. 2020. Stanford University. Document Accessed Online: https://dschool.stanford.edu/.

Hazzenzahl, M. 2008. *Proceedings of the 20th Conference on L'interaction Homme-Machine*. New York: Association for Computing Machinery.

Hollis, T. 2019. *Smart Thinking: Design Thinking*. London: WSP.

Iconics. 2020. *Iconics Automation Software Solution*. Document Accessed Online: https://iconics.com/.

Jayaditya, C. 2020. *Fingerprint Scanner on Phones: History and Evolution, But Do We Really Need That?*. iGadetsWorld. Document Accessed online: https://www.igadgetsworld.com/fingerprint-scanner-history-evolution-but-do-we-really-need-that/#:~:text=The%20world's%20first%20fingerprint%20phone,which%20launched%20back%20in%202004.

King's Cross. 2019. King's Cross Business Partnership Limited. Document Accessed Online: https://www.kingscross.co.uk/press/2019/09/02/facial-recognition.

Lewrick, M., et al. 2018. *The Design Thinking Playbook*. Munich: Wiley.

The light phone inc. 2020. The *Light Phone*. Document Accessed Online: https://www.thelightphone.com/.

Lyonnais, S. 2017. *Where Did the Term 'User Experience' Come From?*. Adobe Blog. Document Accessed Online: https://blog.adobe.com/en/publish/2017/08/28/where-did-the-term-user-experience-come-from.html#gs.h42618.

Mason, N. 2019. "What's the 3-30-300 Rule and How Can Facility Manager Use It?." Office Space Software. Document Accessed online: https://www.officespacesoftware.com/blog/whats-the-3-30-300-rule-and-how-can-facility-managers-use-it.

Memoori. 2019. *Market Update 2019*. Stockholm: Memoori.

Microsoft. 2020. *Power BI*. Document Accessed Online: https://powerbi.microsoft.com/en-us/.

Mikkelson, D., H. Soller, and M. Strandell-Jansson. 2020. *Privacy, Security, and Public Health in a Pandemic Year*. Mckinsey & Company. Document Accessed Online: https://www.mckinsey.com/business-functions/risk/our-insights/privacy-security-and-public-health-in-a-pandemic-year.

Okraglik, H. 2019. *Smart Thinking: Appification of Everything*. London: WSP. ANFA. 2018, September. *Shared Behavioral Outcomes*. Academy of Neuroscience.

Rock, D., and H. Grant. 2016. *Why Diverse Teams Are Smarter*. USA: Harvard Business Review.

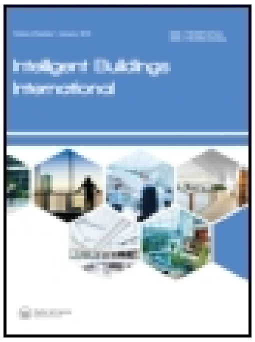
Rossow, A. 2018. *The Birth of GDPR: What It Is and What You Need To Know*. Forbes. Document Accessed Online: https://www.forbes.com/sites/andrewrossow/2018/05/25/the-birth-of-gdpr-what-is-it-and-what-you-need-to-know/#6429e92055e5.

Savage, M. 2018. *Thousands of Swedes Are Inserting Microchips Under Their Skin*. NPR. Document Accessed Online: https://www.npr.org/2018/10/22/658808705/thousands-of-swedes-are-inserting-microchips-under-their-skin?t=1601070482895.

Sheppard, B., G. Kouyoumjian, H. Sarrazin, and F. Dore. 2018. McKinsey Quarterly - *The Business Value of Design*. Mckinsey & Company. Document Accessed Online: https://www.mckinsey.com/business-functions/mckinsey-design/our-insights/the-business-value-of-design.

Stanley, P. 2018. *Designing for Accessibility Is Not That Hard*. UX Collective. Document Access online: https://uxdesign.cc/designing-for-accessibility-is-not-that-hard-c04cc4779d94.

Tech @ Facebook. 2020. *Imagining a New Interface: Hands-free Communication Without Saying a Word*. Facebook. Document Accessed Online: https://tech.fb.com/imagining-a-new-interface-hands-free-communication-without-saying-a-word/.



Taylor & Francis
Taylor & Francis Group

Intelligent Buildings International

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tibi20

The misleading simplicity of designing an intelligent city

M. Marson & K. Goncharov

To cite this article: M. Marson & K. Goncharov (2021): The misleading simplicity of designing an intelligent city, Intelligent Buildings International, DOI: 10.1080/17508975.2020.1856636

To link to this article: https://doi.org/10.1080/17508975.2020.1856636

Published online: 11 Jan 2021.

Intelligent Buildings International
https://doi.org/10.1080/17508975.2020.1856636

The misleading simplicity of designing an intelligent city

M. Marson[a] and K. Goncharov[b]

[a]Arcadis US Inc, London, United Kingdom of Great Britain and Northern Ireland; [b]Terreform ONE, New York, NY, USA

ABSTRACT
Today's designers of intelligent cities have successfully been able to communicate a conceptual model for the technology requirements that fulfil a city's ambitions. The increasing popularisation of intelligent cities has driven this behaviour and populations are now starting to experience the gap between their expectations and reality. This paper considers the new generalist roles that are necessary to deliver broad and complex intelligent city systems. Furthermore, new inanimate users are discussed as well as the ways that standardisation in nomenclature, processing and management are essentials to reduce initial delivery and operational risk. The paper presents an example intelligent city design whose initial stack diagram unravels to present billions of permutations of system interactions. It is concluded that city Chief Information Officers (CIO) have teams that they need to build in order to manage the coming challenges in their operational purviews.

ARTICLE HISTORY
Received 5 October 2020
Accepted 24 November 2020

KEYWORDS
Intelligent; city; standards; design methods; systems integration; generalist; specialist

Introduction

In recent years, Intelligent Cities have been in vogue across the spectrum of designers, owners and operators of the built environment. The mass-market popularisation of Intelligent Cities has led to the emergence of over-simplified technical models for wide-arching systems architectures and requirements (Alexander 2019).

A fourth industrial revolution, or intelligent, city is difficult to define. For the purposes of this paper, it is acknowledged that a fourth industrial revolution or intelligent city is one that employs emerging technologies, in the context of the built environment, that builds on the knowledge, systems and capabilities of the prior industrial revolutions with a particular emphasis on digital capabilities (Schwab 2018).

The promise of intelligent cities is the essence of their popularity …

> the new technology age, if shaped in a responsive and responsible way, could catalyze a new cultural renaissance that will enable us to feel part of something much larger than ourselves – a true global civilization. The Fourth Industrial Revolution has the potential to robotize humanity, and thus compromise our traditional sources of meaning – work, community, family, identity. Or we can use the Fourth Industrial Revolution to lift humanity into a new collective and moral consciousness based on a shared sense of destiny. It is incumbent on us all to make sure that the latter is what happens. (Schwab 2016)

Such strong rhetoric and optimism, coupled with increasing city competitiveness have spurred leaders to push technology agendas.

City CIOs and national Governments are left having to make investment decisions that represent significant parts of a nation's GDP using overly generalised models that give a false sense of security in ability to deliver. Most local and central administrations do not have the expertise in investment

CONTACT M. Marson matthewmarson@gmail.com

decision making or in operations to rapidly pivot to real-time data-driven operations using fourth industrial revolution technologies (Alexander 2019).

This paper seeks to present the technical fundamentals of an intelligent city with an analysis of the failures of convention representation techniques. The aim is to provide decision makers with a realistic view of the complexity of their decisions.

The design and management of an intelligent city

The rise of intelligent or soon-to-be cognitive cities, brings along a number of new roles including the Master Systems Integrator (MSI) (Alexander 2019). Frequently undervalued in the development of Intelligent Cities, the MSI may be an individual (when working at building-scale), or a team for city-wide developments, who plays a driving role in the organisation and the implementation strategy of intelligent technologies.

The common assumption that cities can grow sustainably without these individuals is no longer appropriate for the digitally-driven world in which we reside (Alexander 2019). Whilst in an era of analogue processes, a city is able to withstand multiple overlaps culminated by siloed interventions, as these processes are mostly linear and disparate (Clements-Croome et al. 2017). In the digital age however, communications run through shared networks and a range of protocols add multiple levels of complexity to the process; to reach optimum efficiency, an intelligent city must be holistically organised.

Generalists versus specialists

The skills of the designers and operators of an intelligent city are increasingly being considered as the necessary skills for success are becoming incredibly difficult to find (Alexander 2019). An age-old debate between the supremacy of generalist and specialist roles has been highlighted throughout centuries of human history (Epstein 2019). Our most recent period of built environment design has curated a strong bias towards specialist roles, with examples presented in growing demand of hyper-specific research fields, and a preference for long-term, siloed employment (Epstein 2019). Increasing access to information, consolidated with a change in common practices in the built environment, calls for change in our approach to the design of intelligent cities. As granular control over cities increases it seems that the age of the polymath has returned.

As referenced by David Epstein – author of 'Range: Why generalists thrive in a specialist world' (2019), generalist and specialist roles may be compared respectively to birds and frogs in the natural kingdom. Whilst birds (generalists) have an overarching view of the frogs' processes from above, the frogs (specialists) execute detailed work on the ground. This visualisation pairs well with the organisation and delegation of responsibilities required for successful city-scale endeavours. Such clarity of delegation however, is hard to come by in the development of Intelligent Cities, where designers are encouraged to be 'frogs' and little to no designers are permitted to be 'birds' (Epstein 2019). It is this factor that driving our design habits and intentions to an intelligent city. Oversight of a generalist's value in the work-chain is a leading cause of misalignments, misunderstandings and consequently delays within intelligent city developments. In this context, the Master Systems Integrator embodies a keystone 'bird' on the project – the overarching generalists who delicately unpick, refine and streamline the relationships between all systems utilised within the city.

Another example of the different values generalists and specialists bring, can be drawn from specialist work-chains (Epstein 2019). These function on the thought foundations of assembly-lines, with specialists working in a strict and narrow-minded order. Specialists break down complex systems into siloed tasks which in-turn, improves efficiency and arguably quality. It is important to note, that only when the prevailing outcome is known prior to embarking on construction, does this method prove to be most efficient. In the position of intelligent cities however, contextual intelligence and a wide knowledge base of property technology (PropTech) applications, wellbeing and their technical requirements bring the most fruitful of engagements, whilst specialists struggle to cross-utilise their focused experience.

Change to a city-focus

An industry example of the transition from specialist-heavy work environments to those led by generalists, can be seen throughout the London property market with the increasing body of work in the realm of intelligent buildings, Commercial Real Estate (CRE), industrial sites and city and regional-scale projects. These buildings are structures with numerous siloed teams working to keep the almost self-sufficient ecosystems running around the clock (Barker 2019). The introduction of technology highlights the complex interactions that this well-established industry has. With thoroughly tested methods, the property market starts to experience issues when installing and commissioning new hardware with matching software processes. Without a formal MSI, the leading teams in the maintenance of a CRE asset may begin to collide and dismantle (Biswas 2019). For example, if an intelligent lightbulb stops working, who owns the support ticket to investigate and resolve the issue? There is no clear delineation between maintenance and the Information Technology (IT) department (at a corporate level) due to the blurred line between digital and physical that is created by the Internet of Things. If there is a physical issue with the lightbulb (e.g. end of life, no electrical connection, etc) the bulb must be changed or the luminaire replaced. These sorts of issues would be owned by the Facilities Management team. In the case of digital issues, the IT team would take leadership in the solving of the issue. Problems could include failed firmware updates, firewall changes, etc. This new, cross-analytical problem-solving, requires a generalist team and a strong MSI to execute efficiently – removing any discrepancies between traditionally siloed teams and encouraging more collaborative work streams within back-office teams (Biswas 2019).

The complexities demonstrated by a simple issue at building scale are only exacerbated by the scale of a city and the enhanced scope of their operations.

In light of their cross-disciplinary role, Master Systems Integrators are responsible for a number of foundational components that reduce the complexity of operating an intelligent city (Farrington 2019). Their purview includes a mixture of security and administration-oriented tasks. These may be presented via three key items of ownership: edge processing strategy (1), standards for compatibility (2) and device onboarding (3).

Edge processing regulations

There is an important balance that the MSI must strike between data processing on the edge, at the fog (nearby servers) and the cloud (remote, scaled computing). Devices that need to act quickly should process their data at the edge to reduce latency. Systems that produce large quantities of data, where there is little value in it being analysed, should be processed in the fog. Data that would generate insight is typically pushed to the cloud and processed with more complex techniques. The balance between the cost of cloud consumption, storage requirements and management and latency are contextual and part of MSI's role to define (Hanes et al. 2017; Alexander 2019).

Standards for compatibility

Technically, it is often a challenge to integrate and enable systems to meaningfully transfer, aggregate and transform information between each other (Marson and Kinch 2020). The way in which designers codify their systems is becoming an increasingly prevalent challenge. From a basic level of data management, it is common for different systems across a city to employ a number of different identification or tagging taxonomies for the same assets. For example, a street lighting system might identify a light fitting as LGHT-001, while another system might identify it as LT-001.

If these systems are to be integrated at city-scale, without utilising the same nomenclature, it will be necessary to create an additional (and superfluous) layer of abstraction in the form of a mapping table. Consider the scale at which cities operate, this will increase the processing resource requirements.

To reduce the technical burden in city retrofits, the systems have to undergo the time- and money-intensive process of updating one or all systems with the required ID standard. That same problem arises for new buildings where all systems may have been originally set up using the same asset ID tagging, but through ongoing maintenance and asset replacements the consistency of a tagging system becomes diluted by miscellaneous naming of new assets not in coherence with the previous formatting standards.

> In response to this ever-growing problem, an asset naming standard called Project Haystack was developed [for buildings]. Haystack is open source and specifically designed to be a prebuilt standard that can be deployed at low cost to any building. Haystack, built originally of JavaScript Object Notation (JSON), establishes a clear format through which all building systems can be described, preventing deviation and inconsistency. Haystack is by no mean the only naming standard (Barker 2019). Being open source means that it is in a strong position to maintain relevance through ongoing community contributions as well as being free to use. (Marson and Kinch 2020)

Although no such standard yet exists for cities, there are lots of best practices to be adopted from Haystack as cities work to define their own versions.

In order to understand the relationship between devices acting as systems, an alternative/extension, seemingly aiming to expand the application and learning of Haystack, called Brick Schema was created. Brick Schema seeks to apply a layer of semantic description to make complex intelligent city systems more human-legible (Brick Schema 2020).

Device onboarding

Another key hurdle that must be planned into the design of an intelligent city is the process for standardising the onboarding and verification of devices. Cities, buildings and control systems can often have thousands of digital systems and the process for onboarding and configuring them is likely to be laborious and expensive. In response to this growing expensive and security risk, a consortia has developed a new standard called Manufacturer Usage Descriptions (MUD). MUD solutions are embedded software standards that define an IoT device's intended communications with their host network. Through these standards, an MSI can dictate the access parameters for each device wishing to connect to the host's network, monitor any change in attempts of access and limit sources that each device may interact with. The MUD processes act as a security buffer, providing and rejecting access to authorised devices on a host's network (Farrington 2019).

Together Haystack, Brick Schema and MUD seek to resolve the key technical problems experienced with enhanced integration and deployment of technology within buildings, by providing industry-wide, unbiased methods of data structuring and standardisation. Using the building scale as a test-bed, city designers should take the lessons learned when developing the standards and methods for their cities. Unfortunately, standards can only go so far to nudging city designers and operators towards better working practices. 'The obsolescence of technology after implementation remains unsolved despite these steps towards greater standardisation; the key to overcoming obsolescence lies not with new technological solutions but with well established stakeholder upskilling and engagement methods' (Marson and Kinch 2020).

These three items provide the necessary methods required for stakeholders to create a bespoke city whilst reducing technical debt.

The intelligent cities stack

In order to concisely convey the constituent components of an intelligent city, designers have taken best practice from the field of systems architecture to create a stack model. A stack model shows the layers of components required to fulfil the functionality of a system. Multi-element functionality is commonly referred to as a 'use case' (Hanes et al. 2017).

IoT blurs the distinction between physical and digital (Schwab 2016). Despite this, there are distinct components to consider at the city scale which can be compartmentalised into physical and digital respectively, demonstrated as the bases in Figure 1.

Physical

Physical elements are procurable components that enable the capture of data or the actuation of a software command in the real-world. They are typically comprised of three components (Hanes et al. 2017; Alexander 2019):

Engineering & devices

Engineering and devices focus on the design and hardware required to enable an intelligent city. These could be, but not limited to, sensors, actuators, machines or interactive screens.

Connectivity

Connectivity and communication methods are a core component of intelligent cities as they allow data to be passed between systems and along the stack. Examples would include the hardware to transmit signals (wired or wireless) using a variety of protocols such as WiFi, LoRa WAN, 5G, location beacons and others.

Edge processing and resilience

Edge processing allows data processing and decision making to be kept close to the affected locations. This increases resilience and speed of decision making. At a city-scale, all data being sent to the cloud inflates connectivity and cloud consumption requirements. Examples include onboard processing for devices, neighbour data centres and street-by-street gateways.

Digital

Software elements must be procured to ingest and manipulate data from the physical elements as well as drive logic and decision-making back to the physical layer. Furthermore, visual and

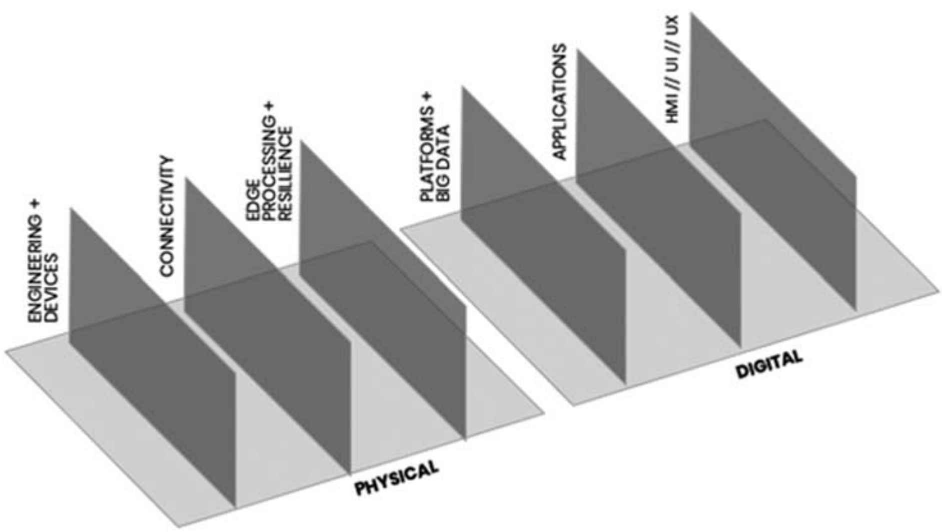


Figure 1. Intelligent cities stack model.

interactive communications with humans is expected from the furthest layer (Hanes et al. 2017; Alexander 2019):

Platforms and Big data

A platform enables data from many sources in an intelligent city to be aggregated, normalised and analysed for useful insights and the orchestration of digital services. Examples include IoT platforms, analytics engines, data lakes, scaled APIs and more.

Applications

Applications manipulate data, visualise data and contain logic for automations and learning. They are connected to data sources such as a platform to enable, services and insights. Examples include dashboards, machine learning preventative maintenance analytics, automation suites and more.

HMI/UI/UX

Human machine interface (HMI), user-interface (UI), and user-experience (UX) all focus on the interactions between people and technology. Examples include voice assistants, mobile apps, interactive screens, online portals and more.

Models such as those presented in Figure 1 are commonly employed by intelligent city designers to describe the requirements of an intelligent city. As a framework, they are able to present the complexity of an intelligent city with easy-to-understand simplicity for non-technical decision-makers. It is this simplicity, however, that leads to operational issues following a system's enablement.

The technical complexity

In a truly intelligent city, optimisations must be provided not only for citizens or their private motivations, but for their non-human counterparts alike. Materials, devices and freight are a key group of new users. Cities that aim to become intelligent, must be equipped for a range of these, as well as alternative communication mediums and service structures. The concoction of new interactions is frequently demystified at a granular level however, as outlined previously, the oversimplification of trans-system dependencies hinders streamlined processes (Alexander 2019). In light of these features, a few key questions may be posed prior to embarking on the development of an intelligent city … Who is the city to be designed for? What infrastructure is needed to execute these ambitions? How do we manage our new portfolio of systems?

Who are the new users?

Materials

Growing awareness around the benefits of circular economies has led to the development of materials' passports – virtual documents (datasets) that provide a detailed history of an item's movements and raw material consistencies. Passports for materials provide multiple post-utilisation benefits: these significantly extend a product's lifecycle, decrease wastage of materials and open up opportunities for sustainable material trading (BAMB 2019). In this instance, the passport acts in a similar manner to a traditional human passport – allowing for material re-integration and supporting it's new 'user' status. The preliminary uptake of materials passports has begun to infiltrate discussions in the built environment and the importance of cleaner construction methods is amplifying in the industry; by providing an accessible 'shopping list' of materials, opportunities for sustainable reconstruction and re-use of building materials rapidly expand (BAMB 2019).

Devices

Devices also earn their status through the personification of their demands; autonomous devices and systems require constant 'healthcare' services, such as Fault Detection and Diagnosis (FDD), to monitor and maintain minimal system downtimes. With a steady growth rate in global IoT end-points of 21% year-on-year since 2018 (Gartner 2019), FDD services are to become vital lifelines for technological ambitions. Devices represent the most interactive of new users; many are equipped to communicate with multiple systems in a number of manners, analogous to human users. As discovered further below, devices can be seen to mirror human needs and expectations from smart systems and their affiliated components. Strategies that hold the devices' requirements in regard to permit systems to bypass human commonalities.

Freight

With the value of the boundary between passenger and freight rapidly diffusing, and a significant rise in New Mobility Services (NMS) (Karmagianni et al. 2016), developers are required to consider more sustainable routes for optimisation. Increasing demand for to-door deliveries, passenger trips and the subsequent growth of MaaS (Mobility-as-a-Service) systems put the needs of the autonomous vehicle as a high priority (Duvall et al. 2019). Critical infrastructure upheavals are necessary to support the influx of autonomous fleets, including 5G masts, fibre connections and curb-side technologies, with McKinsey predicting a 25% increase in passenger trips by 2030 (Hannon et al. 2016) primarily due to the adoption of autonomous vehicles (AVs). A forecasted increase of 92% between 2019 and 2024 in the market value of last mile services in the UK (Mintel 2020), highlights the upcoming pressure on urban infrastructure. Similarly, as humans require 'health and safety' mandates for workplaces and public areas, including capacity thresholds, vehicles also require heightened road maintenance and support facilities such as charging points and pick-up/drop-off locations. Spaces that had once been predominantly designed with the human in mind, such as the curb and sidewalk, will soon be encompassed by AV-dominant infrastructure.

Why is the IoT stack insufficient?

Due to the scale and granularity of intelligent cities, current team structures and academic methods used for city operations are no longer adequate. A key moment of misunderstood complexity lies within oversimplified frameworks such as the IoT stack. As explored earlier, this stack permits the reader to grasp the hierarchy behind different devices, systems and initiatives however, it fails to define the true quantity of permutations and 'inter-connectedness' between layers that typically reside within intelligent city frameworks. From prior experience, we have found an intriguing medium to visualise the numerous relationships created by intelligent cities – the alluvial diagram. Using an alluvial diagram, as a method, should be more thoroughly adopted in intelligent city developments, as new dimensions of information can be quickly extracted, supporting a more streamlined end-to-end process.

Due to their nature and format, IoT stacks cannot provide sufficient technical information about cities. IoT stacks are beneficial for conveying the overarching consistency of intelligent cities however, we need to relay a large quantity of data points with complex relationships, simply and quickly;

Figure 2. Granularity of the stack for City A – implies approx. 36,000 strings of interactions.

the IoT stack only portrays high-level categorisation and the order of possible interactions (see figure 2).

The most valuable information that can be derived from generating models such as the IoT stack, is typical logic chains between the items and layers within the stack. A quick comparison of the two methods used for a precedent project, City A, defines the immense gap in detail that the IoT Stack holds:

Components of IoT stack for city A (see Figure 2):

- 19 individual devices/sensors
- 6 different communication mediums
- 9 different platforms
- 7 different services
- 5 UI/ UX variations
- 2 users

True values within city A (see Figure 3):

- 110 individual types of devices/sensors.
- 12 different communication mediums
- 35 different platforms
- 80 different services
- 45 UI/UX variations
- 2 human users (operators and citizens) – +55 non-human users added to the system

At approximately 9.5 billion individual strings of interactions and dependencies, compared to the ~36,000 suggested by the stack, the perception of complexity within the city has exponentially increased. *How can we clearly map these interactions?*

The alluvial diagram

The human brain is capable of processing visual information 60,000 faster than written information (Vogel et al. 1986). Visualising data has been proven to highlight patterns that previously may have been overlooked. Therefore, where vast quantities of data must be relayed such as complex systems, visual representations of the data are imperative. Through experience working on regional-scale intelligent destinations, with multiple stakeholders and skill-sets, designers are now making use of an alluvial diagram; the addition of an extra dimension to the IoT stack through the alluvial, elevates the legibility of an intelligent city's requirements, see Figure 4.

The near-to-instant clarity of communication load thresholds that are required within the city is a significant benefit of the alluvial. As disciplines specify numerous devices at a variety of stages and

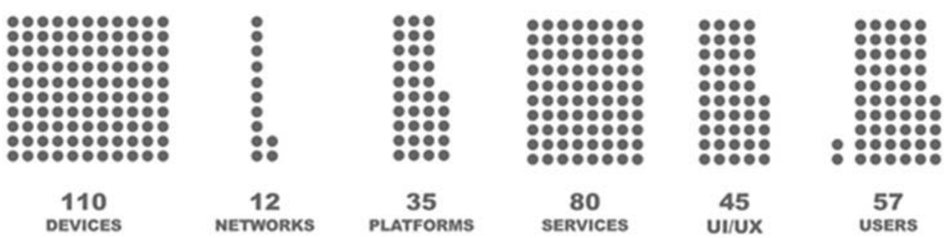


Figure 3. The hidden nodes. True quantity of strings in City A ~9.5 billion.

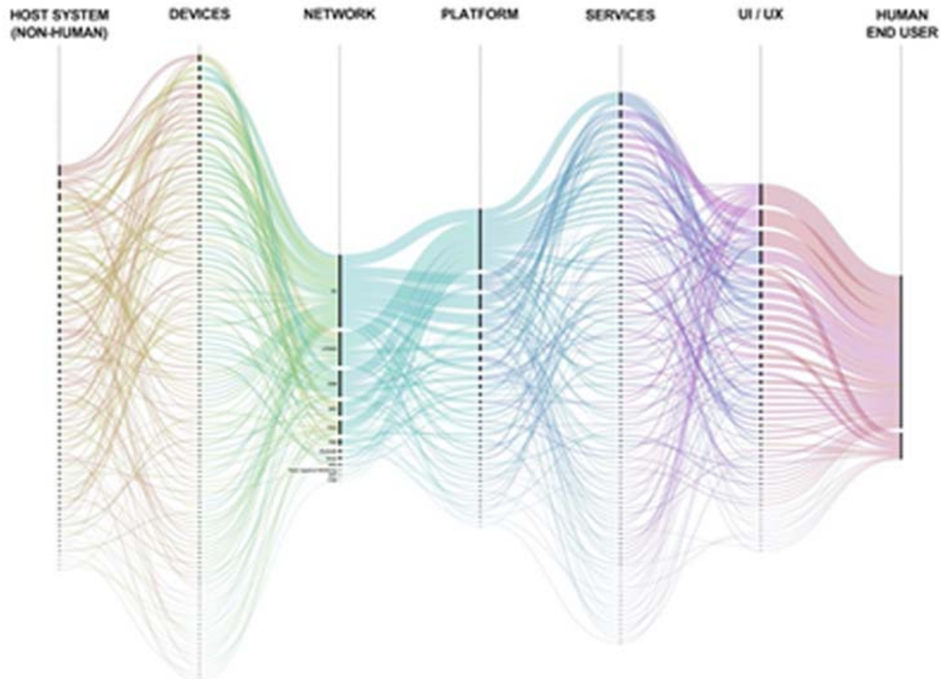


Figure 4. The alluvial diagram for City A.

with multiple communication mediums (5G, WiFi, LPWan, etc.), it is often difficult to project city-wide loads. By organising the devices with their associated systems into such a diagram, development of communications infrastructure may be prioritised based on real-world data rather than monetary or private preferences: the larger the cluster for each communication medium, the heavier the load – see Figure 4. This information confirms sufficiency within plans of each communication medium and provides forecasting capabilities of peak load/demand levels.

Other sectors that benefit significantly from this visualisation include those associated with the platform and UI/UX layers. Processing power and maximum loads are vital metrics to sustain uninterrupted services in the cloud (Srijith et al. 2010); at an individual scale data storage and processing demands may be dealt with by existing vendors however, at a city-scale, processing demands are tailored. As seen with communication mediums, platform metrics are frequently known in post development stages which permits for tangible miscalculations (Alexander 2019).

City planners may find a more novel application for the new dimension of information provided on UI/UX requirements. Implications of under-management of marketing and wayfinding objects placed in public areas may lead to overcrowding and over-use of resources (Miller and Baskin 2019); overcrowding may also be seen in the realm of digital applications due to a myriad of 'City Apps' and other mobile services (Schippers 2016). Consolidating these services enables a streamlined experience for city dwellers and operators alike, minimising points of failure and increasing user engagement (Miller and Baskin 2019).

Multiple other applications exist for the alluvial diagram in complex systems visualisations, apart from those discussed here. New holistic methods of visualisation may also hold alternate optimisations in the way we approach the planning and design of intelligent cities, in a similar manner to that of the alluvial. We believe these to act as a gateway method to more logical and amalgamated direction of intelligent city developments.

Conclusion

Through the arguments and evidence presented through this paper, it is clear that the complexity of designing an intelligent city is difficult to understand at first glance. Populist intelligent city figures and ambitious city leaders spout the benefits of an intelligent city and the concepts necessary for future processes with little understanding of the extent of the challenges and changes required for the design and operating processes.

The role of the designer for an intelligent city requires a generalist skill-set in order to deal with the breadth of issues both technically and operationally. The role of designer must now be more closely linked to that of the operator in order to manage the forthcoming scope of devices, connections, data and processes. The success of an intelligent city will be in the experience and outcomes that it delivers; not the perceived simplicity of the design. Furthermore, new roles, such as the Master Systems Integrator have been created to ensure strong systems, data and design governance for systems that have the potential to have millions of permutations.

A change in the nature of service consumers has also been identified. The abilities of devices, materials and freight have introduced new forms of users to the vernacular of the designer. The considerations of inanimate objects have led to the realisation that standardisation of data nomenclature and processing methods must be standards to give a city CIO a realistic change at dealing with the scale and complexity of an intelligent city. Naming conventions such as Project Haystack (2020) and metadata standards such as the Brick Schema have demonstrated success at the building-scale to rationalise a wide-variety of integrations. Cities are yet to define standards that will support their ambitions in similar ways.

Going forward, designers and operators of cities will need to critically analyse their designs and ambitions against the realities of delivery rather than the perceived simplicity of the conceptual models presented.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributors

M. Marson MEng (Hons) CEng FIMechE FRSA is Sector Director for Manufacturing and Technology at Arcadis. He founded WSP's Smart Places practice.

K. Goncharov MSc is Director of Strategy and Business Development at Terreform ONE.

References

Alexander, J. 2019. *Smart Thinking: Smart Cities*. London: WSP.

BAMB. 2019. "Materials Passports – Best Practice." Document Accessed Online: https://bamb2020.eu.

Barker, J. 2019. *Tackling the Tower of Babel*. London: British Land.

Biswas, A. 2019. *Smart Thinking: Smart for Operations*. London: WSP.

Brickschema.org. 2020. "Brick Schema." Document Accessed Online: https://brickschema.org.

Clements-Croome, D., M. Marson, and Yang, D. 2017. *Planning and Design Scenarios for Liveable Cities*. London: Elsevier.

Duvall, T., et al. 2019. *A New Look at Autonomous-Vehicle Infrastructure*. London: McKinsey: Capital Projects and Infrastructure Practice.

Epstein, D. 2019. *Range: Why Generalists Thrive in a Specialist World*. London: Penguin Random House.

Farrington, K. 2019. *Smart Building Operating System*. Barcelona: Smart City World Expo.

Gartner. 2019. "Gartner Says 5.8 Billion Enterprise and Automotive IoT Endpoints Will Be in Use in 2020." Press Release Accessed Online: https://www.gartner.com.

Hanes, D., Salgueiro, G., Grossetete, P., Barton, R., and Henry, J., et al. 2017. *IoT Fundamentals*. Indinapolis: Cisco Press.

Hannon, E., et al. 2016. *An Integrated Perspective on the Future of Mobility*. London: McKinsey: Sustainability & Resource Productivity.

Karmagianni, M., L. Weibo, et al. 2016. *A Critical Review of New Mobility Services for Urban Transport*. London: Elsevier.

Marson, M., and J. Kinch. 2020. *The Challenges of Retrofitting Smart Systems Into Existing Buildings*. London: RICS.

Miller, D., and J. Baskin. 2019. *What's Your Curb Index?* New York: Coord.

Mintel. 2020. *UK Courier and Express Delivery INCL Impact of COVID-19 Market Report*. London: Mintel.

Project Haystack. 2020. "Project Haystack. Document." https://project-haystack.org.

Schippers, B. 2016. "App Fatigue." https://techcrunch.com.

Schwab, K. 2016. *The Fourth Industrial Revolution*. Davos: World Economic Forum.

Schwab, K. 2018. *Shaping the Future of the Fourth Industrial Revolution*. Davos: World Economic Forum.

Srijith, K., et al. 2010. "Towards Secure Cloud Bursting, Brokerage and Aggregation." IEEE: 2010 Eighth IEEE European Conference on Web Services.

Vogel, D., G. Dickson, et al. 1986. *Persuasion and the Role of Visual Presentation Support: The UM/3M Study*. Minnesota: MISRC, University of Minnesota.

Smart Thinking Podcast

An Introduction

With built environment education largely inadequate for the digital era, I sought to create a suite of podcasts that aided in the modernisation of the skillsets of my peers.

I created the Smart Thinking Podcast as a way to capture the conversations I was having with leaders in the field of Smart Places.

This body of work represents the documentation of knowledge that would not have otherwise been captured through formal academic means. To mean, it serves as a contemporary ‘literature review’ of very recent learnings.

Smart Thinking Podcast

1 – What is a Smart Building?

Broadcast: 14/03/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Matthew: Have you ever thought about what a Smart Building is? What it can do for people that are in that building? How it could be transformative for your business?

How smart are you?

You're listening to Smart Thinking a podcast from WSP. I'm Matthew Marson taking you on a journey into smart buildings. With the launch of our new smart buildings capability globally, we're excited to share with you the all-important ingredients to making a smart building. Over the course of this series, we'll be releasing a new podcast weekly to give you the talking points you need to make your building smart. And you shouldn't just take our word for it. We've invited industry experts to join the conversation. You'll be able to learn more about platforms with IBM Watson, the future of facilities management with Mitie, measuring productivity with Cordless Consultants, exploring the potential to improve healthcare with SMART, and the digital reinvention of engineering.

With a pool of experts from across the globe, we'll be bringing a condensed but comprehensive crash course as to how digital is set to revolutionise our industry. The challenge we are facing is to make the creation of smart buildings simple. As WSP we're starting on the journey to bring together our global capabilities and offers to make sure that they're relevant, insightful, and practical to all of our clients.

Through the creation of a design studio that creates differentiated experiences, a robust management consultancy that looks at the financials and strategy of using technology, or our engineering powerhouse that makes the complex feel simple, or perhaps using our ecosystem to provide Technology Advisory and taking the data that the buildings generated to gain deep post occupancy insight.

Expert 1: There's a lot of debate about what a smart building is these days, and a lot of, I'll call it snake oil out there around what it is.

Matthew: Through the course of making this series, even defining a Smart Building has been difficult. But here's what some of our experts had to say.

Expert 2: What I think a smart building is is a building that is agile, a building that learns and adapts.

Expert 3: A building that tells you what it's doing.

Expert 4: Very much about connectivity, how we extract information from the building, how users can use the building more effectively

Expert 5: The connected building where all of the subsystems, they're all connected together.

Expert 6: Any building that is designed to be fully integrated into a data or algorithmic pipeline.

Expert 7: A smart building to me is a building that comes to life.

Matthew: Let's just give that a little bit of context. If we were to take a hospital for instance, imagine if your lighting system actually provided the right sort of circadian rhythm such that your body can help heal faster. What if you're at a stadium and you're watching your favourite sports team? Could you have your snack brought to where you're sat?

Smart evolvable buildings integrate intelligent design, multiple data inputs, and previously disparate systems that aggregate these into a cloud of useful information. When harnessed this actionable intelligence allows smart owners and occupants to create more engaging and effective built environments. In fact, truly smart buildings maximise the value of each and every square metre. From reducing energy consumption and operational costs, to more effective maintenance and space utilisation, and increasing users well being safety and productivity.

Linking your building systems together is advanced automation. Taking the data and doing something with it adds intelligence, but creating new digital services that benefit an occupant, now that's smart. It could be a mobile app that helps me find colleagues in real time with a particular skill. Maybe it's proving how much healthier my home is in comparison to other buildings. Or it could be something that works in the background to increase the sustainable credentials of where I shop. The way that smart buildings cross so many different disciplines, service lines, departments, both internally and externally, it will change the way that we operate or the tools that we use. I call it the digital reinvention of engineering. To create some of the things I've mentioned, we're going to have to think about engineering more holistically, consider how software could enhance our designs, and most importantly, put people at the heart of what we do -- concentrate on human-centred design.

The formula is simple. We call it Smart Simplified: integrating technology, purposeful design, and actionable data equals optimal managed performance and happier, healthier users.

In our next episode, we'll be looking at the value of a smart building.

Thanks for listening to our first episode, and I'm excited to take you on a journey into smart buildings.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking a podcast from WSP.

Smart Thinking Podcast

2 – The Value of Smart Buildings

Broadcast: 21/03/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Matthew: As part of my role, I often get asked: Isn't this just a set of gadgets? Isn't it just another cost for my building? How can it actually help me to contribute to our business objectives? Often corporate real estate can be considered a cost centre, when in fact smart buildings can help reframe it as a driver for strategic value.

You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into smart buildings. In this episode, we'll discover how you can use a smart building to create value for your business. Smart buildings are not just for large companies. In fact, they work across residential, communities, cities, and more. In fact, it could be your stadium that's smart, it could be your shopping mall, and more. If we boil down the C-Suite goals into their fundamentals, they are essentially to increase revenues and to reduce costs. Smart buildings technology can help us address both of those streams.

Firstly, let's look at increasing revenues. Smart building technology can help with increased productivity per employee, increased innovation and collaboration, and increased talent attraction, and retention. So let's say that for most white-collar workers, around two hours of productivity leakage occurs a day. And that can be everything such as the Wi Fi dropping, the lift being out of service, or even the toilets being cleaned at the wrong time of the day. We can now use sensors and cloud computing to understand the places in which an employee is leaking productivity. In fact, one study found that using this sort of technology can actually help reduce productivity leakage by around 15%.

Next up, it's increased collaboration and innovation. And often it's found that using this sort of technology can increase your innovation index by around 83%. And that's by using things such as location services to help people find places things, people and their skills, which means that people can collaborate and work on projects that might be out of their comfort zone even faster. And finally, to also increase revenues, where smart buildings technology has been seen to be a success is through increased talent attraction and retention.

If we take The Edge in Amsterdam, by developer OVG, then Deloitte has found they've had real success for their business in attracting talent. In fact, in the first 18 months that they were in this smart building, they were able to grow around 167% because everybody was really up for working in a smart building. It's also been fantastic for their brand, reframing them as an audit firm into someone that you would trust with complex digital technology delivery projects.

On the other side, there's reducing costs. Again, smart buildings technology can help with this. Firstly, let's think about reducing employee absenteeism, or reduced occupancy and service costs, and finally reduce utility and maintenance costs. For the individual, we can start to reduce absenteeism by making it a healthy space. The International WELL Building Institute says that having their standard in place reduces sick days by 28%. And now that sensors and cloud computing are at a competitive price point, you can start to prove some of the more fluffy business cases, or at least that's how they've been considered in the past. For instance, if you can compare the levels of carbon dioxide in a space, which is the gas that we breathe out, when it gets too high in a space, it reduces your concentration. And in some cases, people suffer from what's called sick building syndrome. But if we can prove that actually making the spaces more healthy, in real time, links to reduced number of sick days in your HR system, then we've proven that smart buildings make healthier buildings.

Next up, it's reduced occupancy and service costs. By understanding how people are using spaces, it means that you can be much more frugal with additional space that you might need to let. For instance, let's say the engineering team say they need six more desks and the marketing team want to hold on to the five they already have. We can now make facts based decisions by understanding how often those desks are actually used, or even produce heat maps from a set of occupancy sensors to understand the circulation routes that people take, how they're moving around the space, if you've got the adjacency of your team right, or even which technology is the most popular so you can help drive investment decisions, and finally, reducing utility and maintenance costs. HVAC analytics enables you to monitor what's going on on the building management system and fix any deviations from your design intent. In addition, watching that data and understanding what the machines are doing on a part by part basis, means you're able to identify any maintenance issues that could occur before they actually do. And for most companies that use this sort of technology, they typically save between 10 and 25% in energy consumption, and around five to 15% in maintenance. And why this matters so much is because most businesses incur operational expenses per employee per day. For most, it's around $3 on energy $30 on real estate, and 300 on the person themselves. And the reason we've been focusing so much on energy in the past was because it was very simple to prove your bill is either lower or it isn't. But given the technology that we have, and the associated analytics, we can now start to tackle the 30 and the 300 bucket. From this, you should be able to see the value that a smart building can deliver, be that increasing revenues, or reducing costs across your energy, your real estate, and your people. When considering the return on investment for smart technologies, it's very easy to get spooked by the large numbers. But if you consider the savings that you're going to make or the potential uplift in revenue, then the best way to assess the return on investment is by payback period. For instance, if you're looking at heating, ventilation and air conditioning analytics, if you have a payback of around two years, then that's good for a system that might operate over five.

Our next episode is the Rookie's Guide to the pitfalls to avoid when embarking on a smart building.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking a podcast from WSP. I'm Matthew Marson and thank you for listening.

Smart Thinking Podcast

3 – Why Smart Buildings are Difficult

Broadcast: 28/03/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Male Speaker: We don't do that here.

Female Speaker: That's not my department's responsibility. It's just another set of problems.

Male Speaker: What happens when it goes wrong...?

Matthew: ...Are just some of the things that people say when they're faced with the prospect of a Smart Building.

You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into Smart Buildings. In this episode, we look at the complexities of creating a Smart Building, and the pitfalls to be avoided. Smart, evolvable buildings integrate intelligent design, multiple data inputs, and previously disparate systems that aggregate these into a cloud of useful information. When harnessed, this actionable intelligence allows smart owners and occupants to create more engaging and effective built environments. In fact, truly Smart Buildings maximise the value of each and every square metre.

There are eight reasons why Smart Buildings can, if not executed correctly, go wrong. Firstly, there's the skill gap. There's people, devices, standards, connectivity, security challenges, big data, and analytics. Firstly, when we consider the skills gap, often when it comes to Smart Buildings, there's no real formal training. It hits a lot of different markets and crosses traditional siloed boundaries. In fact, you need a plethora of skills from across the business operations and engineering to really make that successful. And if you consider how construction projects are managed using a traditional waterfall system, where delivery has to happen one stage after another, that kind of misaligns with how software engineers work in more agile methodologies, where different buckets of functionality don't necessarily go in the order that you would expect them to be delivered.

If you think about people, as well, in a Smart Building, sometimes they can be afraid of the new technology. They're concerned that it'll be watching them and that their privacy might be at risk. Some essentially don't like change or new ways of working. And there's a lot of misunderstanding about the business value and the imperative for why somebody would do that.

Thirdly, let's think about devices. They give you additional overhead during your lifecycle of the building. It fundamentally changes how you manage your assets. Sometimes there are difficulties with standardising the onboarding process for those IoT, or Internet of Things, devices, and the protocols in which they speak are different from those that facility managers are most comfortable with.

Fourthly, if we think about the standards, we need to shift towards more open source standards with the appropriate bodies, and their supporting open protocols. Most often, we're locked into a particular vendor, and legacy means that we have to stay a part of that ecosystem. And we also need to declare who owns the data, particularly when you're in a multi-tenanted building.

In terms of connectivity, moving forward we need to make sure that we design our networks so that they're converged but also segmented using software. This means that although you have only one physical infrastructure, you can essentially run it as if it were multiple separate networks. This is really good for ensuring cybersecurity. In fact, we need to also start having more control on the profiles that we give to devices so that if we expect them to speak across the network in a certain way, and they change their behaviour, we can identify any security breaches.

Number six is security challenges. As with everything, backdoors exist, and we need to mitigate against those sorts of risks. Perhaps that's through software base rules and device profiling. Maybe it's just having a commitment to ensure that you roll out updates and are really conscious about security within your organisation. Or perhaps it's having the need for encryption or certificate-based authentication across your network.

Next up it's big data, and that changes the way that you might architect your systems within your business. If that's having an API based architecture, having a set of globally accessible protocols, making sure that your organisation has a really strong data etiquette, and having consistent relationships and schema.

And finally, it's analytics. Start with a use case defined approach for data matching, such that if you know you're after a particular thing, then you can go and design the exact system to support what you're after, rather than worrying about how you tie it all together at the end.

In my opinion, I think we should start with a visual design first because it's visuals that really help explain the outcomes of some of this technology. And finally, have a lightweight display method. So you don't have a set of really complicated applications that are difficult to unpick later.

The end to end process for delivering a Smart Building is really quite complex. Once you've kicked off your project, we all need to be singing from the same hymn sheet. And that's having a shared vision, maybe even producing an experienced design so we can understand how people are going to feel in the space, or what they're going to say about it once they've left. Having a strong strategy, modelling out those business cases to ensure that the technology is going to have proper business outcomes for you, and then understanding the devices and machines that you need to select, how you're going to connect them together, how that data is going to be processed, particularly for resilience. What sort of platforms are you gonna use? What are your big data methods that are going to make this successful, particularly when you start to render that on an application? Are there any other systems within your business that you should be integrating, for instance, if we can compare the amount of daylight in a space to how often people sit at their desks, or even the outcomes that they deliver, that would be really valuable. How about the user interfaces that you need to see and provide value to the normal folks that are using the building? Then once you're ready to go, how will you deploy and commission some of this hardware? How will you test it to make sure it's successful? Have you considered the change management that you're going to have to put in place, or perhaps even the support model to help both your OT and IT folks work together? And finally, how can you continue to drive success through the operations phase?

Smart buildings often run into challenges. But if you can get a smart building right, then it will be transformative in terms of the outcomes that it delivers for your people, your profits, and the environment.

Join us in our next episode with special guest Kamran Moazami and find out why he thinks buildings of today are the cars of yesterday.

If something in this episode has piqued your interest, then have a chat with us. Email Smart@WSP.com. You've been listening to Smart Thinking a podcast from WSP. I'm Matthew Marson and thank you for listening.

Smart Thinking Podcast

4 – Smart & Holistic Engineering

Broadcast: 04/04/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewees: Kamran Moazami – Managing Director, Property & Buildings, WSP UK. Jane Richards – Head of Structural Engineering, WSP UK.

Kamran: The thing that is exciting for me is this holistic engineering. We want to go into the future. We want to have buildings that they are exceptional. We want to have buildings that they are smart.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into Smart Buildings. In this episode, we're discussing how engineering is changing. I'm joined by Kamran Moazami and Jane Richards. Kamran Moazami has over 37 years experience in structural engineering and has been responsible for the design to completion of over 30 million square foot of building projects across the globe. He's our Managing Director for property and buildings in the UK, and a Milne Medal winner, and has worked on some of the most prestigious high-rise buildings around the world. Also joining me is Jane Richards who's been working as a structural engineer for over 30 years, is head of the structural engineering practice for the UK and has won the Best Structural Engineer by Women in Construction and Engineering awards. Jane's specialisms include tall buildings, stadia and modular. Welcome, Jane. Welcome, Kamran. The first question that we'd like to ask you is: What's your view on Smart Buildings, and why do they matter?

Kamran: Well with the today era of technology and where we are heading, I think the future of the building design is about the smart technology. We have done this, I mean over many centuries probably on the car design -- the development of the car and automotive design -- and it had reached the point that cars can drive themselves, and they think, they analyse themselves, they tell you which tire has less air. Also it tells you when the service is required and what part of the car requires repair. So, why doesn't it apply to buildings? Future buildings are car of yesterday, and probably with the amount of technology that is coming online, I mean we will have buildings that analyse themselves and they tell you where the problem is. They optimise the performance and we will live in a building that tells you what is required for the building, how you could repair it and and how you could maintain it.

Matthew: I'm really interested to hear a little bit more about how you're pushing for a holistic approach to engineering design and moving away from single business lines. Could you tell us a little bit more about that?

Kamran: Well I mean it's simple. If you think about it, all part of the body works and function together. Every element is to communicate with other element to learn about other parts of the body, and then overall you have the best organism. I mean, the same thing is for the building. If you make sure that each engineering part of the building is working together in conjunction with the rest of the element, obviously you will have a much, much much better building. And it's just that engineers just focus and they are really into what they're doing. When they come out of the box and they think about other systems involved in a building design, they actually learn that it's more exciting, because at the end of the day you come up with something that is better, is more advanced, and what you do works in combination of other parts, which again makes it better, makes it more exciting. More than anything else you become part of a team that comes up with the best solution. It is the solution that is important. It's not...and it's the overall performance that is important. It's not each part individually doing its own thing the best way possible.

Matthew: So do you think that the skills to be an engineer are changing?

Kamran: Not really. I think the communication is changing. Interaction is changing. Understanding each other's needs and working together to come up with the best possible solution is the difference. Focusing only on your area of the work is going to optimise the solution for, say, structural engineering, or for mechanical engineering, but working together to find the best solution, placing the core where it belongs, and making sure the fire system works with the structural system, and make sure that the facade and the mechanical is working together in the best possible way, and you fire engineer the whole system to make sure that it is optimum and in the right location and with adequate engineering input to it. So, ultimately, if you look at it holistically and your mind frame is about holistic design, then obviously the end product is going to be a much better product chain.

Matthew: Jane, if I can ask you, what is your vision for holistic engineering, and how does this relate to Smart Buildings?

Jane: Relating back to what Kamran said earlier about the human body being similar to a building, what we want to do is to start really approaching our design as one holistic engineering team. We've all got our different skills in terms of the functions that go on towards a building design. Think about one another's discipline functions and bringing those together a little bit more naturally, so that we're taking a single approach to a building design. In terms of smart buildings, I mean, I see this is an exciting extension of this whole building approach. It's extending our services into the operation of the building, so it's enabling people to get more from their buildings, get a better experience from their buildings. What I think is great is that everyone wins by applying it -- the owner, the tenant, and the staff using the building.

Matthew: One of the things that's really exciting to me is last mile delivery and how drones will be a part of that. So as a structural engineer Jane, is there something clever that you could do to allow drones to fly into the building and around it without the structure becoming floppy?

Jane: I think that's less difficult for us to achieve. In terms of providing access for drones to actually fly into a building and then gather data once the building is constructed, I think that's all doable. When you think about plant replacement strategies and so on, it's another up front sort of thinking strategy for how we're going to make that provision in the building. One of the things that I think would be really interesting to explore with drones is we do a lot of off-site manufacture design, and that's starting to become more and more a key part of the construction industry going forward. And I'd like to think there was a way where that highly automated QA factory approach for getting the modules say constructed in the factory, if we could apply that on site during site installation, maybe combined with the use of drones so that we've got that fast loop feedback of data that could be analysed, and then adjustments made in the factory environment to suit what was happening on site, that would be a really interesting application to start to study for use of drones.

Matthew: If you were a client who wanted to embark on a smart building, what would your advice be?

Jane: I think my advice would be first of all to just step back and ask a bigger question. Have a conference or a questionnaire to actually explore what you're really trying to achieve overall with the building, and then smart becomes part of that answer, I'm sure. And it's a bit like what we're trying to do with our holistic engineering approach. Actually you can get a lot more by joining a whole load of things together than just going after one thing. But smart actually is the thing that now takes us into the operational part of the building, which really is exciting because it fits so well with the design of the building itself, and then in its long term use becoming a much better experience for everyone.

Matthew: A big thank you to Kamran Moazami and Jane Richards. The next episode is an interview with special guest Nick Offer, who invites us to the Python club.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP.

Smart Thinking Podcast

5 – The Digital Transformation of Engineering

Broadcast: 11/04/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Nick Offer – Head of Building Services, WSP UK

Matthew: Just a quick reminder, this series takes you on a journey into the world of smart buildings. If you're interested in design, digital technology, and the future of buildings this is the podcast for you. This is Episode Five.

Nick: Smart buildings are our future. They're required now. Our tenants need them. It's up to us to wake up and provide them.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into smart buildings. In this episode, we're talking about the digital transformation of engineering. And joining me is Nick Offer, who's the building services head of discipline for WSP in the UK. By trade he is a mechanical engineer and actively supports site plans in design and strategy. He is the key to bridging the gap between yesterday and tomorrow. Welcome, Nick. First question for you: What is a Smart Building, and why should we care?

Nick: I think -- thank you for that wonderful intro -- a smart building to me is a building that comes to life. Many of the buildings we design and deliver, they, they've got control systems and operating systems in them that people don't understand, that users don't understand, and the people that run the buildings struggle to deal with. A Smart Building changes all that and enables a building to be used in a different way by the people that run it. It simplifies it, bring complexity to life, and then more importantly, enables the users and the people that want to work in that space to have an interaction with the building, understand it, work together with it, find each other in the building and interact.

Matthew: With that in mind, how do you see digital shaping engineering in the future?

Nick: I think there's an awful lot about to change and I think we've already started. The first thing we're beginning to do is understand that there is change around us, that buildings are going to be automated, that buildings are going to need to be run and designed differently. And we're also beginning to see that we need to design them differently ourselves. We're beginning to automate our process. We've already started this, and it's really helped us have more time to think about how we work. But there's a lot more to come and we're going to begin to automate all of what we do.

Matthew: Okay, so what steps are you taking towards digital engineering?

Nick: We've got an awful lot of young people in our team, and people that have come through thinking very differently about computers. And we've got programming clubs. We've got a team that meet once a week, and they have a Python club. And this is really enabling us to look at the process of how we work, investing in people to give them time to think and work very differently and automate the process. We've also invested in bringing people into our business that write automated tools and software. And we're beginning to then take it even further where the lion's share of the work we do will start to be designed automatically.

Matthew: During our prep for this podcast, I remember you telling me about a piece of software that you've had developed, which looks at where things go in the ceilings.

Matthew: Could you tell us a bit more about that?

Nick: Yes. What it is at the moment, we might spend six to eight weeks slowly working ourself around the load of a building. We calculate how much heat can come into the building. We then work out what the loads are. We'd go and select equipment. We'd then design that equipment. We'd work out the flow rates for the heating and the cooling. We'd draw it all up and it could take weeks. We've got a piece of software that does all that automatically, and it can do it within half an hour, and then draw it in 3D and create schedules of all the equipment that it's made for. So it completely starts to change the process of how we work.

Matthew: And what does that mean for our clients?

Nick: For the clients, it means we've got more time to think. We've got more time to coordinate. One of the things in our industry that's been difficult is the 3D element of our work. It's becoming so much more complex and we're showing our clients far more than they've ever seen. The more they see the more they think they should see. So our biggest challenge is time and complexity. So if we generate and keep more time, we'll have more time to coordinate, and more time to get our job even better than we do now.

Matthew: So how do you think the workforce will evolve, given the development of these sorts of tools?

Nick: I think we're already beginning to see it. We've got quite a young workforce, not, I may just, but we've got quite a lot of young people coming through our business that think very differently. I think we'll see a lot more of that. I think we're seeing people begin to think very differently about how they work and how they want to work. And if you think something can be done differently it probably can be done differently. So I think our people will be more empowered. They'll have more time. They'll have more automation around them, which gives them time to investigate, to think, to coordinate, to work together as a team, and to help the client understand the journey he's on. Building services are really complex. I've often said that a building services engineer defines a problem that you didn't know you had in a way that you don't understand. And I think with more time going forward and more automation we'll enable our clients to understand what we do.

Matthew: So do you think it's a different skill set that an engineer will have to have?

Nick: I think it's the same skill set. I think the same knowledge, the same college courses, the same work, the same background to understand engineering and understand buildings. It takes time. It's complex. There's a lot to learn. But the process of spending weeks going through flow rates, and adding flow rates together, and defining schedules, and making equipment will be shortened, which will give greater level of time. So I think the skills are similar, but I think as the more modern age come through that are more tech savvy, we're ready to embrace that and we're ready to work with them.

Matthew: I can almost see a future with slightly different roles. So for instance, rather than having someone that designs and does the calculations, perhaps they need to still have the understanding of it, but actually supervise some of the decisions that are made by some of these automated tools.

Nick: Obviously in my career, I spent 10, 15 years learning how to do my job, and through that process you understand the loads. You understand that when you're working with plant and equipment that you've got the right size equipment. Very often if you'd let some of your young staff size plant and equipment for you, they get plant that's the same size as the building because there's things that they made errors with. So it's important that we have checking processes and checking procedures. The other thing that happens in our industry, we design to building regulations, so we meet specific criteria. That means it's very easy for us to check back to watts per metre squared, for example, whether the building's the right load.

Matthew: What do you think to how building services will evolve as we add more web-type standard technologies into the building to control them? Do you think the days of trend in the traditional building management system are numbered, or do you think there's still a way to go?

Nick: No, I think they're very much numbered. I think... the only reason I think there's a way to go is because we've got a lot to understand, and we've got an industry around us to try and convert to get them to think differently. But I think it's going to be incredibly exciting. I think it'll happen at a pace. I think we'll see more and more automation, more and more smart ways of working, more and more cloud-based services. I use an iPad for my daily life and my daily work. I can swipe up on my screen and connect to objects around me. That's how we're going to run our buildings. It's all about to change.

Matthew: So that means, surely there's going to be more complexity by increasing the number of integrations that are required.

Nick: I don't know. A bit of me thinks it'll be more simplistic, because instead of the complexity of how it was working before, if I can have access to something, see something, and then I can work with it, that will enable a building to come to life. Most of our buildings now, the users can't understand the control systems. They can't go into the control systems. They can't modify them. But with certain levels of access, we're going to be able to see people integrate with a building in a way they've never done.

Matthew: Which I think might be something that these digital forms of technologies will be opening up. If you think about the investment that we've put into the more front-end type devices such as mobile apps, building controls have never really had that. So, it will be, I think really exciting to see what happens to our industry.

Nick: Oh, I think it's hugely exciting, and I think it's now. I think the tenants looking at buildings want this now. They want to understand how the building they're going to lease or go to work in is going to be smart for them. But immediately right now we're not quite designing these yet. We're just at the forefront of getting started.

Matthew: And my last question for you: Let's say you are a fresh grad, and you've just joined building services, and you've got the horizon of this bold, bright, digital engineering future. What would your three top tips to them be?

Nick: Okay. I think my first one would be: Have an open mind. Try to understand the complexity of what we design and the simplicity of how we could use it. So if we have an open mind and we think about what we can do, that will help us head in the right direction. I think we need to really investigate, and understand, and make sure we train people to see how these things could work and how we can interact with a building, and then head in the direction. And we need to inspire our clients as well as our engineers. We need to show people what these systems can do, and how they're going to change how we work and run with our buildings. So, there's pretty exciting times to to come.

Matthew: A big thank you to Nick Offer, Building Services head of discipline for WSP in the UK. In our next episode we'll be comparing our own industry for the sorts of things that the financial services sector has done. Listen to a very special interview with Tom Hollis, who has our head spinning with blockchains, crypto assets, and artificial intelligence.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

6 –Digital Services & Service Design

Broadcast: 18/04/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Tom Hollis – Proposition Design, Market Gravity

Tom: This is about making your work more like your life and blending that line so that you're happy to go above and beyond because you're truly passionate about what you're doing. And I think a physical building and a space has a huge, huge component part of what that looks like from an employee experience.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into smart buildings. In this episode, we're exploring the importance of design and digital services. Joining me today is Tom Hollis a management consultant who is helping global businesses experiment with new ideas and take them through to scaled products. At present Tom is focused on the capital markets industry, helping investment banks, our asset managers, understand where value can be found in a new market of blockchains, crypto assets, and artificial intelligence. Welcome, Tom.

Tom: Thank you, Matt.

Matthew: So getting to the theme of our podcast today, in your own words, Tom: What is Service Design?

Tom: So, I'm going to approach this backwards a little bit, and explain first what it isn't, and try and debunk a few myths, and then come around on my humble offering of a definition. But one of the things we constantly see, and particularly with the word design, is that it's about what it looks like. And the best line I've heard on this is design is not about how it looks like; it's how it works. It's practically how a system or set of services operate together around a True North, which is the user. Equally, particularly in a lot of the consulting world, and I imagine it might be so in engineering as well, people look at it as a methodology. They latch onto things like design thinking, and now design doing as a cookbook of things that you can put together to solve a problem. And it doesn't really work like that. It's much more akin to a set of different lenses that can be applied to a problem when you're trying to explore it. So if you think about how you would solve for a Rubik's Cube, you constantly turn it around in the first instance to look at multiple different size, multiple different angles to get as deep an understanding of a problem as you can before you solve it. That's how I think about a lot of at least the design principles, and approaches, and methods that they use. Now when you combine those things together, and what I think underpins particularly our interest in design at the moment is really that the dogged absolute True North of the user. Everything is built around what the user wants, how the user wants to do it, to what intent, or what ambition the user is trying to get to, and how we can help them achieve that. And although that tends to come down with things like you know, use, you know, and this word 'use' is a difficult one because it tends to get you into: Okay, but everyone uses my product. They have to use my product, particularly in a B2B instance, right, within a company. Well we're not gonna be, we don't want to think about design because they have to use Outlook, or they have to use like my email client, or whatever. But use actually has some very powerful economic implications. You know, consistent use is retention and, as we all know, customer acquisition is the most expensive part of customer management. So if you can hold onto them and get them constantly using your product, that has a big impact on both your top and bottom lines. And then equally, if you want to make that very real you look at Apple, right. There was a meme going around a while ago that compared the new Samsung phone to the new Apple phone. And when you looked at the Samsung phone it said, 'Well I had this feature in 2009. I had this feature in 2012. I had this feature in 2014.' All these great reasons technically why you would choose a Samsung phone, and the retort was, 'Yeah but this is an iPhone.' That brand affinity that's been built up over time, and they just do the little things really well, so it can come down to for some very tangible realistic things.

Matthew: Have you got any good examples of where you think people are getting their digital services wrong?

Tom: Yes, lots. I think if I was going to prioritise them, the absolute first one is there's somewhat of an obsession with technology. When we talk about digital, we automatically flip towards talking about new technology. And then in my world, my current world in investment banking and capital markets, that's all Artificial Intelligence, that's all Big Data. It's all now Small Data as well apparently is coming back in. There's distributed Ledger's and blockchains even Bitcoin now we're starting to talk about again.

And really that, for me, is a symptom of companies looking at the leading companies at the time and seeing lots of technology. And they look at Google and they see technology. They look at Apple they see technology. They look at Netflix, in particular, and they see the things they do with distributed computing, and having rogue systems that run around and take servers offline to keep the technical team on their toes, and they see all that great stuff and they think oh, it's all about technology. It's not, you know. Not every company is a technology company. Every company is a digital company and they have to be relevant in a digital environment and a digital customer. But that doesn't necessarily mean you need to focus absolutely on technology. And that tends to have a knock-on impact as to how a business tries to approach, you know, developing digital services. It means they organise themselves around specific technologies, and what can I do with this toy, what can I do with that toy, instead of thinking about where am I gonna make money in the future? Through which digital mean can I make, you know, improve a customer's experience, or a user's life? How can I improve retention through various digital ways of thinking and the new realities?

So that would be the first one, and actually by extension the second one, which is treating things in silo, not looking at the top line: What is the business trying to do, and how can we organise all these tools we have? Yes, but different ways of approaching a problem. You know, not trying to manufacture everything ourselves but pulling capabilities from outside our business through platforms, or marketplaces -- all of those kinds of things.

And then I think the third one would probably be looking too big, and it's definitely a symptom, or a challenge with big companies who are used to operating in global markets thinking big projects, big scale. They tend to focus on the big. Whereas, actually if you look at some of the guys who really get this right, and it's a small section, it's less than a fifth of companies who are really good at this, but they tend to produce outsized results in terms of revenue uplift. If you look at what they look at when they approach digital services, they look very small. They don't look at big mega trends. They don't look at competitive...what the competitors are doing. They don't benchmark themselves, necessarily. They don't look at the average customer. They look at the specific customer, the very, very small niches that go underneath them, and they use that, the here and now, and the real, and the small to inform how they point their products.

And that comes down to my last point actually, which is most companies really, when you look at it, don't have that level of depth of their user particularly not at scale. So, you know, we do tend to work with the averages. And I would hazard a guess that the average millennial that tends to pop up in all of our planning and digital strategy sessions doesn't actually exist. You know, no one really sits on that average. There's massive, massive different varieties and flavours of millennial that you can get. And if you try and aim for the average one, you're probably going to miss all of them, you know, to talk about one demographic in particular.

Equally we test with them, so you know a big proponent, particularly in design, is testing early, testing with paper prototypes, and that's a really, you know a difficult thing for big companies to do who are used, you know they got a brand to defend. They don't want to put something out half-baked. So they'll delay, and delay, and delay, and delay and before you know it, you're 18 months down the line in developing a service, but you still haven't really, you still haven't shown it to a user. You've shown it to a couple of employees maybe, maybe friends and family, but they aren't necessarily, you know, the user who's really going to power the growth of a product and your top and bottom line.

And then, I think the final point on that user angle is really most companies haven't switched from a gathering requirements mentality to an understanding and challenging assumptions mentality. We still go in there with a checklist of: We think this. What does it need to do, as opposed to trying to understand the user, maybe more than they understand themselves, to try and think of product services that they're a little bit ahead of where the user can really communicate it? You know, there's something in there, there's an intent, there's an ambition that the user is trying to achieve. It's about trying to walk backwards down that journey with them. And if you're going in there looking for requirements for a build as opposed to understanding why they want to engage with the service, what they're trying to achieve outside of that, you know, narrow interaction you have with them, you're gonna probably miss a lot of useful stuff.

Matthew: I wholeheartedly agree. From my experience, when I talk to my clients, it's a case of: Well what technology can I put in the building or, you know, maybe I need this gadget for security versus something else to do the lights, and they don't really think about how it ties together. I ask them: When was the last time you actually spoke to someone that uses your building? Do you really understand what they want, not just the person buying the space? And I think that's caused a lot of the satisfaction gap that people have with the buildings in which they work.

Tom: I think, actually there's a question I've probably got for you on that, you know. If I look at a lot of the companies I deal with, you know, they've spent a lot of money over the last 10 years now trying to optimise their technology and automating as much as they can, moving things to the cloud. They're trying to make the system smart. You know, we're trying to squeeze as much productivity we can out of our technology, but our total productivity line is flat. And if you look across the UK, productivity has been flat for a while. You know, so my hypothesis would be, or actually maybe there's a lot on the human side of things that we've probably under invested in. How do we improve the productivity of our humans? And that's doubly important if you think in the future, you know. Most of the automaton stuff will be done by machines and what's left will be traditionally unproductive things like creativity and whatever on the right-hand side. And so I've got a couple of interesting clients who are looking at how they can use their building to do that. And I know you've done, I think, some work on that in the past. You know: How can you reduce sick days? How do you create a working environment that drives one's productivity line? And companies are now starting to look at that through a very, very strict strategic lens because they understand that, you know, simply making your machine faster, and updating to the latest version of Microsoft isn't necessarily going to deliver those gains that you're really trying to look at, particularly when you're also looking at: How do I make it more innovative, or more creative, or more entrepreneurial? You know, how do I make them happier? How do I attract tech talent, you know because, I mean crikey, like Google don't really compete with you on, on price? You know they'll compete with you on, on your quality of life working there. And, you know, for a lot of ambitious, driven people, I don't think there really is a work/life balance. It's about making your work more like your life and blending that line so that you're happy to go above and beyond because you're truly passionate about what you're doing. And I think a physical building and a space has a huge, huge component part of what that looks like from an employee experience sort of angle.

Matthew: What would Tom's top tips for compelling service design be?

Tom: So I think, the first is be very disciplined with your questions. Most designers will spend almost all their time on trying to understand the problem, and a little bit of their time trying to solution for it. There's an Einstein quote, whether it's Einstein or not is a big question on Reddit, but to that effect. And I think there's a, you need to ask early, yes, but also ask innocently. Don't go in there with loaded questions. And that's a really hard thing to do. And equally if you're asking early, that is a really uncomfortable to do, particularly for a big company. You know, going in there and looking like you don't know the answer to the question, or looking like you're trying to understand them better, or putting something in front of them that is, you know, an early paper prototype -- that is uncomfortable. What we've seen work the best is where you work with either an agency, or someone you hire from the outside who's from that sort of environment and from that assumption to help get your people more used to doing that sort of thing, because it is very uncomfortable. And you feel very naked in front of a customer.

Second would be: Don't chase the shiny. You know, be stylish not fashionable. And I definitely learnt that through the front-end experience at the FinTech company. And then, I guess the latter one is more understand where you're going before you start. Too many people say: We need to do something digital. We need to do something with this technology, without walking it back up to a very specific strategic question for the boss, or their, ultimately their company. And even things like improving user experience have a metric attached to them. You know: Is it retention? Is it conversion? Is it activation? Is it referral? Like point to something particular, and in particular point to something that's very small and specific, what I would call a leverage point. Something that if you lean on it a little bit, it's gonna have a big impact down the line. And I'll kind of illustrate that point with a really great story from a guy called Dave Trott, who is an ex ad man, quite famous in the industry. Definitely look him up on YouTube and look at his books because it's really, really clear thinking. And he tells a story about, he was working at Sainsbury's on one of their campaigns, and it was at the time in the UK where you've got, you know, Tesco and Sainsbury's really slogging it out for market share. And Sainsbury's had an ambition to grow 3 billion in three years -- new revenue -- and you know, thinking, you know, how do we do that, through discounts? How do we get, you know, how do I get 300 billions worth of new people through the door? And you know, they were tackling with a big $3 billion problem, if you want to look at it that way. And all of the junior ads guys in the account said, "Well hang on, we have 14 million store visits a week. You know, so surely over a three-year period if we just got everyone to spend an extra £1.50 a week, we, we'd hit the target." And that was brilliant because you turn a $3 billion problem into a very small, very manageable £1.50 problem. And you know, not everyone will spend £1.50. Some people would spend a ten quid. But if you average £1.50, you know you solve your problem. And because you've looked at the problem through that lens, through a different lenses, using design techniques, you've aimed for something really, really small that sticks with people, that can be measured, that, you know, you can anchor a lot of what you're doing around. That makes the thing that comes out the other end, be that a new product, a new service, a new way of doing things, whatever it might be, that much more likely to stick and that much more likely to deliver something that's going to ultimately contribute to the growth of your business.

Matthew: Incredible. Service Design is something that we're going to use more and more here at WSP as part of our smart buildings offering, and all that remains to be said is a big thank you to Tom Hollis for joining us.

Join us in the next episode when we discuss how Cloud Computing is whipping the traditional building management system into shape. We'll be discussing heating, ventilation, and air conditioning analytics.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

7 – HVAC Analytics

Broadcast: 25/04/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Milesh Patel – Director of Solutions, ICONICS UK

Milesh: On average we're seeing about 8 to 10% savings in your energy costs.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into smart buildings. In this episode, we're talking about heating, ventilation and air conditioning analytics, or HVAC analytics for short. Joining me in the studio is Milesh Patel, director of solutions at ICONICS in the UK. Milesh works across all industries and his speciality is working with real time data enriching it with other data sources in an organisation and delivering contextually rich, easy to maintain dashboards and visualisations. Welcome Milesh. First question for you: What is a smart building, and why should we care?

Milesh: Hi, Matthew. So for me, a smart building is a building that tells you what it's doing. And that's really important in this day and age where you're thinking about, you know what is the energy consumption that my... that my building is using? How are my employees behaving in terms of their wellness and their productivity? By being able to measure what a building is actually doing, you're able to make adjustments and tweaks and start to optimise the way that the building, and in the end, the occupants are actually behaving.

Matthew: So what are HVAC analytics and how can you see them helping?

Milesh: HVAC analytics is a set of software that sits on top of the existing building systems, plugs into all the various systems that the building has and starts to pull out trends and patterns, and start... identifies potential issues that are causing any particular problems in terms of your heating or cooling, or you know, just in terms of your general occupant wellness. So we're able to take that information and we're able to generate suggestions on how you can tweak and optimise the building behaviour.

Matthew: Okay. Have you got any examples?

Milesh: A really good example that we've got is Deloitte's new headquarters here in New Street Square in London. It's a building that is a flagship for Deloitte and it incorporates pretty much any and all sensor platforms that you can think of. We're combining occupancy, environmental data, room booking systems, BMS systems, all in order to identify how the building is operating and to be able to tweak and manage how it works across the various floors.

Matthew: Okay, so does that mean you can do things such as a real time occupancy adaptation? So let's say for instance, a meeting room has been booked but nobody actually turns up. Does that mean we can step back some of the energy consumption?

Milesh: That's exactly what that means. Because we're taking various pieces of information that typically by themselves wouldn't make a lot of sense but by combining them together, we can very much be more efficient. So we're turning off the air conditioning, because after five minutes we can see that there's nobody in the room, even though that room has been booked, therefore, you know, increasing your energy efficiency.

Matthew: Okay, so when you start to add it to other things, it becomes much more powerful. But let's consider what at its heart of HVAC Analytics. Am I right in thinking that it's essentially a set of energy analytics that looks at all of the different points, so you get a glimpse into how individual machines within the building are working, and then also, fault detection and diagnostics? So, in addition to knowing what the energy is doing and how the machines are behaving, you can then also start to see how bits and pieces within the machine might be deteriorating over time. So it kind of gives you the ability to predict what's going to happen before it actually happens.

Milesh: Yeah, exactly. So there's a two-fold part to that: the energy and the FDD that you're referring to talks about the physical assets in the building. So what are my fan cool units and air handlers and all the various bits of HVAC equipment that are in the building to maintain tenant conflict doing? And by analysing the performance of those assets, using the energy analytics and their fault detection modules, we're able to optimise the maintenance schedule for that, and to keep the assets running as efficiently as possible for as long as possible. Tie that into then the rest of the data that comes from, you know, things like occupancy, and the room booking systems and you're then able to make multiple optimizations to the building, because you've now got access to a vast amount of data that you wouldn't necessarily have had before.

Matthew: Okay, and what kind of savings are you seeing from successful implementations of this?

Milesh: Typical savings that we're seeing varies depending on the building, but on average we're seeing about 8 to 10% savings in your energy costs. And that is by having the solution running for a period of at least a year, you can expect to see those kinds of gains -- a process that we call continuous commissioning.

Matthew: Okay. What kind of client issues are you seeing, and how do you think this sort of software helps?

Milesh: So one of the main issues that we see in typical buildings is the disparate nature of these various systems. Every system sits in isolation, doesn't talk to anything else, and you know you've got systems that are heating up a building at a set schedule because that is, you know what they're used to, and yet you've got a room booking system which is able to tell you whether half the building is occupied or not. So the fact that those two systems are disconnected from each other, and that's the normal use case, is one of the key issues that we see. So unifying the various data sources across the building is really important.

Matthew: Could you give me an example of how a client has have been able to use HVAC analytics for business advantage?

Milesh: So in terms of energy savings, we're doing a lot of work with clients who want to optimise and reduce the cost of their buildings. So we have a governmental client who has energy analytics and fault detection running across multiple facilities. And what they're able to do is review what their energy bill is over the course of the year, look at what optimizations can be made by the software over a period, and from that take really strategic decisions. So, in essence, is this building too expensive for us to actually run even if we're trying to maintain it, in which case, let's not build this building anymore. So it's making really big strategic decisions on looking after your portfolio, based on the energy and the fault detection data that comes out of the system.

Matthew: So that's actually really quite powerful for an organisation, and the sorts of savings that it can deliver for a business. It's incredible. Quick question for you then: If you were an organisation that wanted to deploy HVAC analytics across your buildings, what would the top tips be?

Milesh: For me, the top tips would be: Think about integration. Think about making sure that you have the sensor data that you need and it's available in an open platform. We talk a lot about building standards, and a lot of the new buildings tend to use all of the standards. A lot of the old buildings don't have that, and it's really important to try and make sure that your data is available in an open way so that you can have multiple tools extract that data and make use of the data rather than it being locked up, you know in your BMS system, or in any of the other systems that you've got. So open connectivity and integration is the key takeaway that I would have.

Matthew: A big thank you to Milesh Patel director of solutions at ICONICS in the UK.

In our next episode we prove smart lighting isn't just about occupancy sensors. Jay Wratten wows us with the benefits of its bi-directional communication and how lighting is the key to unlocking a building's smart potential.

If something in this episode has piqued your interest, then have a chat with us. Email Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

8 – Smart Lighting

Broadcast: 02/05/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Jay Wratten – Vice President, WSP USA

Jay: Light and architecture, are inextricably intertwined. And going forward Smart Lighting and smart buildings will be inextricably intertwined.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into smart buildings. In this episode, we're talking about an illuminating topic – Smart Lighting. Joining me this time is Jay Wratten who is vice president of sports at WSP USA, an award-winning lighting designer, and smart building strategist. Welcome, Jay. First question for you is: What is a smart building, and why should we care?

Jay: What I think a smart building is is a building that is agile, a building that learns and adapts. Simply connecting a bunch of devices together and having a dashboard that says what's happening today is great and we can learn a lot about it. But what we're aspiring to do here is create buildings that conform to what the users want from them today and in the future, and that might be totally different than the expectation we had when we opened them. And so really, I think we're on a journey to get there. There are some aspects where we have smart buildings that really do respond. But it takes the right amount of planning and coordination and solutions, right, so.

Matthew: Lots of people in our industry seem to think that the key to producing a really good smart building is to use a smart lighting solution. So could you tell us about what a smart lighting solution is?

Jay: I think that lighting is becoming a really important component of smart buildings for a couple of reasons. Light is everywhere. So anywhere we have a space that people are in we typically have lights. Those lights are in the ceiling, so they go in as part of the building's infrastructure. And they have consistent power. So it places lights, and lighting controls in a prime position to be the sensory network or enabling network for a number of smart building devices that we might want to create datasets from in order to allow that larger goal of a responsive building. So I think when we think about lighting there's two components. There's a Smart Lighting Control System ability to respond and adapt to their users. So that could be something like learning when people typically come into the office, anticipating those times and turning on ahead of them. It could be changing the spectrum of light's quality in order to reinforce the circadian rhythm of the folks that are in the space.

Matthew: And what is a circadian rhythm for those that might not know?

Jay: Sure. Circadian rhythms -- so our bodies have a clock. And that clock is reinforced every day by the rising and falling of the sun and the change in spectrum of light that that creates. There are receptors in our eyes that detect that are called ipRGCs that detect a certain wavelength of light, and that helps set our body's clock that keeps us awake at certain times of the day and asleep at other times of the day. Now the fact that we are inside 90% of the time means that we aren't necessarily getting enough natural light stimulation to reset that clock, and it can result in short and long term health issues for people that live in buildings for the most of the time. And so there's a number of researchers and interesting data coming out around the role that electric lighting plays in reinforcing or unintentionally screwing up that circadian rhythm. So it's part of a smart lighting solution, not the only part but certainly on the forefront.

Matthew: So are you saying that Smart Lighting could actually help with health and well being?

Jay: Absolutely. Absolutely. It's early days, and when we start to get into health and well being, I think we need to be careful about talking about lighting as medicine, right. This isn't the dose or a prescription. But at the same time there is growing evidence that we can do harm, and so therefore we should be doing good and lighting plays a great part in that.

Matthew: So, so far, we've spoken about Smart Lighting being able to adjust to schedules and the things that people are doing on the inside, to health and well being in terms of circadian rhythm. And what are the features of the solution have you seen?

Jay: A couple of things. So, one of the big transitions that lightning has made in the past, let's call it decade, has been the transition from our traditional lighting sources incandescent, fluorescent, metal halide to a solid state, or digital source, which is LED. That transition brought lighting into the digital, let's call it that, and it enables us to more easily have bi-directional communication with the light fixtures, meaning that we can tell them what to do – turn on, turn off, dim etcetera. But they can tell us things like: I've been running for this much time. I'm consuming this much energy. I'm malfunctioning. So one of the components of Smart Lighting then becomes a way to better service the building. So that's one aspect. The other aspects, now that we're into digital, is that it's very easy to put additional data gathering sensors onto fixtures, because they are sort of already that network and so that Smart Lighting System now becomes a network to report that data back to this larger smart building.

Matthew: Wow. So you're saying that because the sensors are in the ceiling you've essentially got full view using sensors of things that are happening on the floor?

Jay: Yes. So occupancy is a great example. Lighting code, and most of the world is now requiring us to have something called an occupancy sensor in most spaces. It's an energy saving device. It's a maintenance device so that if I'm in my private office and I leave, the occupancy sensor shuts off the space. What we have seen as a result of that is occupancy sensors starting to show up all over buildings. What a connected or smart lighting control system allows is not only does that sensor, which is in the building, now telling the lights to turn on and off, it gives us a lot more valuable information about how people use the space and allows our building to better respond to that use.

Matthew: I remember working with a high growth tech company once who wanted to use the occupancy sensors for just that sort of thing. They were struggling to keep up with the demands from different teams as the business was growing so quickly. So they were able to use the data from the occupancy sensors to keep a track of exactly what the usage was so that they didn't have to go and take extra rentable space, and they could really kind of flex the space in the best way it was working, and also to help justify some investment decisions for different types of work setting given the neighbourhood scheme that they were using. So it's really interesting to see how in some cases lighting systems that already have this capability are unlocking entire new use cases. So with that in mind, what are the sorts of challenges that you're typically seeing from clients now, and how are you responding to them?

Jay: I think, simply getting all of the connected lighting and other smart systems to aggregate data into one place is a challenge. So we've traditionally built, designed and built I should say, buildings in silos: our HVAC engineer, our lighting engineer, our security engineer, right, are all building systems. Those get built in silos by contractors or subcontractors whose sole responsibility is that system. When we start to look at a smart building where the occupancies data from the lighting control system contributes to these other outcomes, it becomes critical that that data has a way to get to that larger platform. So one of the challenges is making sure that the building is designed and constructed in order to enable that outcome. A second challenge that we're seeing is a skills gap. So, our traditional developer or facility manager hasn't been tasked with using the kind of real time and historical data that we have. They may not even have someone whose responsibility that is to do those sorts of things. And the client that you mentioned before is a good example where we're starting to see new job titles emerge out of smart buildings. So, you know, we're starting to see clients that have chief workplace Digital Officers, right, whose job it is to look at the data that these buildings are generating, and then drive that into decisions and outcomes. And so the skills gap is something we definitely need to address. And then thirdly, I think, trying to get, I talked a little bit about connecting things together, but trying to enable that sort of open sharing of data, a standard format, a standard protocol for how data is exchanged is another challenge that we're seeing. And we're coming out of a space where most of the solutions are proprietary or were proprietary historically. And it is a paradigm shift to start to think about your individual solution, if I'm a vendor sitting in this larger ecosystem of data, right. And so we're trying to break down those historically proprietary walls and show vendors that there is business value for them in sharing the data and being part of a larger solution, even if they don't own all of it.

Matthew: If I were a client and I was interested in pursuing a smart lighting solution, what would be your top tips?

Jay: Well, I think it starts with why: Define what you mean by smart building, and why it brings value to you or your business. We've talked a lot here this morning about technical solutions, what we're doing to enable a responsive and agile building. But if it doesn't make business sense, and you don't have a strong driver for doing it, the top tip would be, you're probably going to fail. You'll either fail in execution, or you'll fail in planning, or you'll fail downstream because you're simply not using the data and the opportunity that you created. And you won't be able to assign a revenue stream or a business value to the cost, which we should be honest is not nothing in the context of a smart building, so I think the top tip is to really go through that, that strategy, the roadmap, understand why you're doing it, and make sure that you are engineering solutions, and outcomes that support that reasoning.

Matthew: A big thank you to Jay Wratten who's joined us on live link from Colorado.

In the next episode I'm joined by the director of connected workspace at facility manager Mitie, where we'll be discussing how actionable IoT data is used in the real world.

If something in this episode has piqued your interest, then have a chat with us. Email Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

9 –Smart for Operations

Broadcast: 09/05/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Anindya Biswas – Director of Transformation, MITIE

Anindya: This is an industry in transformation. We are at the very early stages, compared to many other industries. And the data and technology, be it Artificial Intelligence, IoT, is going to completely transform the way facilities management is delivered.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into smart buildings. In this podcast, we're talking about how to operate a Smart Building. Joining me in the studio is Anindya Biswas, who is the Digital Transformation Director at Mitie. He leverages data and technology to improve the way that facilities management is delivered. Firstly welcome, Anindya. And the question I have for you is: In your opinion, what is a Smart Building? And why should we care?

Anindya: Thank you, Matty. A Smart Building is all about using data and technology to improve the quality of services to the users, and the operation of the building in itself. So it could extend into, you know, how the visitors are using the building, how the energy of the building is taken care of, how the maintenance regime is sort of offered. So there's an array of areas that we can work around with. However, every building has its own characteristics, and we define the Smart Building propositions around those characteristics.

Matthew: Could you tell me a little bit about what you're doing at Mitie? What is Connected Workspace?

Anindya: The idea behind a connected workspace is: How can we improve the way we deliver our facilities management services to the users? And so it operates on two core pillars. The first pillar is all about improving the performance of the building. And the second pillar is around improving the user experience. And apart from that, we operate in six key imperatives around, you know, around facilities management. The first one is about user experience. The second is all about the usability. And third is around how do we improve the utilisation of the buildings? The fourth area would be operators around the sustainability of the building. The fourth area are more focussed on the hard FM pieces of it. The fifth area is about the resilience, and to ensure 100% uptime of all the critical assets. And the sixth area is to move from an input to a risk-based security module.

Matthew: So it's a pretty all-encompassing offering?

Anindya: Pretty much it is. And traditionally, if you look into, you know, smart offering around building, they've been always working in silos, and so whether you're monitoring environmental conditions you just monitor that. But what we're doing is we create that central repository of data where we can look into the utilisation data, what is the impact of utilisation on developing to the sustainability, and then the maintenance and the critical infrastructure? So you get a holistic view of the entire building rather than a silo view.

Matthew: And that must give you a pretty powerful voice with some of your customers.

Anindya: Yes. So the route to market was, again, we, we took an investment-led sort of an approach where we started proofing of concept. We invested in lots of POCs with different customers. And at the moment, we're collecting a lot of data and information about those POCs and going back to the customers with the Proof of Concept, with the business case, and now scaling it up with some of the largest customers of Mitie. So it's quite an exciting journey at the moment.

Matthew: But it's quite a big step to go from Proof of Concept to something that's scaled. How have you done that?

Anindya: So the business case, so, you know, during the POC is very well-defined in terms of what data we're collecting. What is the baseline information that we're going to measure against? And once we've proven that sort of portion, and that piece of the information, and that was the magic basically, and after that it was easy for us to create that business case. For example, you know, with Red Bull we were looking at environmental condition and impact on people's productivity. And we've seen the CO2 level was increasing during lunch hours in the afternoon time of day, and people -- productivity had fallen down quite drastically. And then we changed the BMS control of the building and monitored again, and we saw the productivity level increased. And Red Bull did an independent study and they found the impact on productivity about 10 to 12%, which is a significant charm. And if you talk about, you know, a space with about 100 employees, an average salary of 50,000 per annum, 10%, 12% increase in that productivity level is a huge impact on business. So it's a no-brainer basically.

Matthew: Five K per year, per employee.

Anindya: Yeah, absolutely.

Matthew: And how were they measuring productivity?

Anindya: The productivity was measured typically in the timeframe basically: How much time you typically wasted during a day on organising different stuff and things like that.

So with connected workspace, we were able to improve that productivity quite a lot actually.

Matthew: That's great. And beyond productivity, are there any kind of key issues that you keep seeing again and again from your clients?

Anindya: So many customers, and utilisation, especially in London real estate is a massive issue where we find utilisation of a particular property is quite low, that's the FM managers feel, however, a lot of employees generally say that 'We have no place to sit and work', and that's a typical challenge that we constantly face. And the FM managers with our customers, because of lack of data they struggle to sort of justify the case. For example, we recently did one study with, you know, an organisation which was accrued through mergers and acquisition, and every organisation that they acquired around their own portfolio, and so steel buildings in Leeds operating at 50% utilisation level, but they have two different assets sitting on their portfolio. What we did was after that study, we closed down one building, improved the utilisation of another building by about 78%, from 50, and that's how we were able to save a significant amount of money. Apart from that we also run, you know, guaranteed, you know, energy performance contracts where we do the procurement. We do the demand side management and the demand side response out of it, and improve the energy patterns, and energy consumption in our customers. And there's a gain shared model, which customers are subscribing into.

Matthew: Wow, so it sounds like you're basically kind of tackling the three big buckets cost that a company feels...

Anindya: Pretty much.

Matthew: Energy, the space that they're in, and the person themselves.

Anindya: Absolutely.

Matthew: It's a really powerful offering. I wanted a bit of advice from you. Let's say that somebody wants to use IoT to improve the operations of their Smart Building. What would your top tips to them be?

Anindya: So any IoT device that you're currently using, I mean the technology is evolving so quickly, so we have to be very cognizant about what technology you need to put in your organisation. Cost is an important factor that you need to put in place. Also, whatever IoT device you are installing in your offices, in your environment, there has to be an open API. The data needs to come out of that organisation so that you can use it in multiple ways. So open API, costs, these are two important barriers. Apart from that, you also need to look into, you know, what kind of technology that you're using. There's so many technologies out there, and currently we are using a lot of LoRaWAN-based technology. But there are devices made for NB-IoT, and SigFox, and various other networks, so, you know, what kind of network you're operating in, you have to choose those devices accordingly.

Matthew: So that's quite interesting. Does that mean that you're not using the existing IT infrastructure that your customers already have?

Anindya: Oh we definitely use the existing IT infrastructure, as long as they have open API around it. And we find some problem around say room booking systems. A lot of suppliers have closed protocols around it, and with that closed protocols, you're not able to extract that data to use it any further. For instance, you know, a large number of organisations we see, for every particular service you have a different app, and the employee experience is absolutely horrid because you have 20 different apps for doing 20 different things. Ultimately you basically require one app which then can interact with multiple devices through the open APIs on the gateway

Matthew: And have your customers' IT organisations been supportive of what you've been trying to do?

Anindya: So, there's always that INFOSEC clearance, which is quite critical for most of the IT organisations, you know, because it has to be outside the network. It should not interfere with the WiFi connectivity. So we tend to use, you know, more Bluetooth-based technology rather than WiFi-based technology, because there's a lot of, you know, security-related issues that we come out with. And some of these INFOSEC approvals take about six to nine months time. However, you know the times are changing, people are evolving, and so the resistance to change is a bit of a challenge. However, it's coming down now.

Matthew: What are the biggest things that Mitie has learned since they've used IoT to operate your customers' buildings?

Anindya: Managing the whole data set is a massive, you know, massive challenge that we need to sort of address it absolutely head on, because we're talking about terabytes and terabytes of data coming into your system. How do you manage and handle that data is quite critical? The second area is around that tool device management piece because you're talking about installing millions of IoT devices across a customer's portfolio, and how do you manage that? So creating that whole Device Management and infrastructure around it, whether you buy it, or partner it, or build it, it's absolutely critical. So these two are the most important elements, and then creating those business rules around the data, and what are the threshold, what are the barriers, you know, and how do you use that data to create insights and take actionable measures are the three major learnings that we've done so far.

Matthew: Am I right in thinking you've actually invested in a team of data scientists?

Anindya: We do have a team of data scientists. Our head of data sciences, a former Googler, so. We're learning a lot about the kind of probabilistic model that we're operating in, these local machine learning curves that we operate at the moment. So, yeah, it's quite an exciting journey.

Matthew: Who'd have thought that even five years ago that a Facility Manager would have a data science capability?

Anindya: Absolutely. Absolutely. I mean this, this is, this is an industry in transformation, and I'm quite happy to be at Mitie at the moment because we're pioneering this space. Lots of organisations are doing multiple, you know, they're approaching the mark multiple ways and, however, you know our approach was, again, very investment led. We put an investment in technology, in people, and we are gradually seeing some changes around in the market.

Matthew: Fantastic. Thank you for the advice. A big thank you there to Anindya Biswas, Digital Transformation Director at Mitie.

Anindya: Thank you.

Matthew: In our next episode, we'll be talking to Miguel Sosa about his experiences of working within a Smart Building.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

10 – Human-Centered Design

Broadcast: 16/05/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Miguel Sosa – Senior Account Executive, Delta Airlines

Miguel: How can a physical building actually provide the community that your employees need?

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into smart buildings. In this podcast, we're talking about what it's like to work in a smart building. Joining me today, having flown in from New York City, is Miguel Sosa, who's a smart cities legend, and former director of IoT innovation at the management consulting firm Accenture. Welcome, Miguel.

Miguel: Thanks so much for having me. Great to be here.

Matthew: So let's talk about The Dock. It was very much Accenture's experiment to see how you could apply technology in the built environment and how that would lead people to be more innovative.

Miguel: This is correct. So at Accenture, one of the goals was what would happen if we brought in different groups of people across our entire enterprise, and basically smashed them into one building to see what the creative process would entail.

Matthew: Just to set context here, The Dock is Accenture's Global Innovation Hub, which is a building that has 66,000 square feet of space and has over 10,000 sensors collecting around a million points of data a day.

Miguel: You really couldn't do that in an ordinary building. We wanted to also create an example of a building that would bring technology experiences and enablement for different ways of looking at the inhabitants that we have, to share with us some things that we could then perhaps scale across our enterprise. I'm looking forward to talking about that today.

Matthew: So how would you describe your experience of being in a smart building?

Miguel: Sure. So I've worked in many buildings, as I'm sure all our listeners have. And for most of us, we can probably think of the cubicle environment that we may have worked in, or we can think about a building that didn't respond to our needs. And what I found fascinating about working at The Dock, which is over in the Dublin Docklands should you be in the area, was that we were able to anticipate people's needs from the beginning. So whether it was looking at digital badging and how that mentally enables somebody to feel included from the very time they begin at the company, whether it was having a different way for people to find each other to help improve efficiency but also to build community. So for example, we created an app that allowed people to actually identify thought leaders within the building. We also had different ways of adding desks and sitting and standing desks. We were able to capture data on how many people were there. We even connected weather sensors, Matt. Weather sensors to enable us to tie that back into the building's HVAC system and controls, to ensure then on days of hay fever and high pollen count that our inhabitants, and those that were there as tenants, were breathing clean air. And that made a difference physically for me and the people that were there.

Matthew: When you brought clients around the building to show off the technical prowess of the centre, how was it perceived? How did people respond to it?

Miguel: That's a great question. I think we had a mixed bag. So you had some clients who were just absolutely in awe. Those that have been in traditional brick and mortar buildings without any technology whatsoever and are now understanding the power that they can bring to having insights. So for example, as we look at workforces that are working more from home, and are having more valuable time allocated to where they're working in a building, it's important to know what those folks are doing, and how they're using the building, what their needs are, what they're asking for, and do it in real time. And that to some people was really intriguing. I think to others, one thing that they were curious about, there are a lot of quote/unquote smart buildings that have come about over the last five six years, and I think people are trying to understand what is the value add? So if I go about adding technology, is it just for technology's sake? Is it for a fun lobby experience, or is it providing valuable information and an experience that attracts talent in a world where we have a war on talent?

Matthew: And do you think you did?

Miguel: So I do. I think that for me when I walked around the building and I talked to newcomers, some who were millennials, some who have been in the workforce for a while, it felt to me that they were proud to be in that space. There were people who were proud to speak about what they were doing. And for our operations team, I think they're just scratching the surface now, but it gave them a different prism with which to view, and see, and focus their energy as they go about serving the people that they are there to operate with every day.

Matthew: Now what we designed was something that was supposed to deliver business results in terms of the actual day to day function of what the whole centre was about across the environment, and for our people, but I think some of that wasn't as successful as we'd hoped. What did you see as being a couple of the biggest problems with the technology that was deployed?

Miguel: Sure. So, with any given smart building, as with a smart home, as with a smart car, the question was about what stage of the technology are you actually procuring? Who are the companies that are actually developing and deploying it? Do they have a track record, or is this their first time doing it? Because we were a living lab, we went with certain vendors that enabled us to really try it out together. I think if you're looking at scaling, you're going to need a WSP. You're going to need a firm that understands how to bring the technology to a much global scale. And we did run into some issues. And I think that one of the things I would advise our listeners and those that are considering what the value of smart is, is to realise that this is not just straight out of the box, that there are going to be some things you need to work with, and customise, and plan for, but if you have really smart thinking from the beginning, you're looking at the human centred design and being able to bring stakeholders in from the very first planning meeting across all verticals, I think you're gonna have a really remarkable product.

Matthew: What do you think, on the flip side, is the most successful thing about the building?

Miguel: For me, the most successful thing, and I'm a community person as you know, Matt, was the ability to make people feel that they were part of a much broader and bigger thing. And for a building to actually enable that -- here we are thinking about a building that traditionally we thought of as a static object. But now the building itself is playing a living, breathing role in bringing together people who are able to share ideas more quickly, feel that their needs are being met, and are having fun. That to me was success, the fact that we could attract talent, whom otherwise would have picked other companies had it not been for that building. That to me was fantastic.

Matthew: It was really interesting technology that we were looking at. The building actually has the capability to know that you and I are in front of one of the kind of six foot tall kiosks there and say, you know, Miguel you like space, Matt you like drones, maybe you two should go and make space drones. And I just think that's such a powerful thing to do in a community.

Miguel: It's really remarkable to be able to share that and to have a space that brings the best out of all of us, and especially in a world where there are people who may be more introverted, may be more focused on those elements that are individual task contribution. How do you bring people together in a way they've never experienced it before? And that's, I think, what we were pushing for. And much of the success and congratulations to you on building that up very well.

Matthew: I find it really interesting that a building is taking on a new role to act as community maker. And with the thought of community, we actually had a little bit of success with the local authority.

Miguel: Yes. So, as we think about the role of buildings in a broader community, I now look at what the Dublin Docklands are doing. Under the administration of Dublin City

Council, brilliant leaders like Jamie Cudden, who are looking at how do you take buildings to actually inspire development, and now in this area, you're looking at Facebook, you're looking at Google, you're looking at Airbnb, and how they're transforming their campuses to build an entire economic ecosystem that can just really push the technology envelope forward. So for example, they're now going to experiment with 5G, and have a micro testbed for that. They're going to take a look at how connected lighting plays a role both in security, but also telling me foot traffic, so I can now use that information to cater to retail stores and what they're doing. I think that scaling from a building to a city obviously makes sense and something that I've been passionate about doing. And I see an entire world there for people to explore as that interconnectivity provides ultimate value both for the shareholders and business owners, but most importantly for us the customers and clients that want great things to happen.

Matthew: Do you think it's the technology that will help develop the community in the Docklands area?

Miguel: I don't think technology alone. So I think one of the challenges is if you lead with technology first, you're going to fail. I think you have to lead at the same time with both what are the needs of people today, five and 10 years from now, and then understanding what technology empowers them. And when you lead with people first, you can then solve for people problems. If you lead with outcomes first, you can solve for outcomes. I think if you put technology in for technology's sake, it provides a benefit for being able to experiment, but you might be solving for things that don't need to be solved for, and I think there's a better way of being more inclusive in that design thinking process.

Matthew: And design thinking was the methodology that we'd use to curate this experience, I suppose. We didn't start with technology. It was something that was, we, you know, kind of worked out how to do once we had got what the True North was, if you like, and we'd kind of mapped the journey that some of the staff would be going on during there, not just how they would interact with pieces of technology but the fundamental processes and what it means to make place.

Miguel: I think from cities to buildings to car manufacturers and everything in between, we're seeing a fundamental shift into design thinking and design led development. That is so critical, because again, we're able to paint a much broader picture of what the outcome should be and who we're solving for, and that is so broadening and not limiting. And then that enables us to think about what do we need. So what are the things that we need to build? And that, I think, was part of the success of our experience and story at The Dock and something I've seen carried through as more and more organisations follow that methodology.

Matthew: Now, I'm looking for your advice. If somebody was wanting to embark on creating a Smart Building, what would your top tips be?

Miguel: If they were starting on a Smart Building, I think I would start first with: What are your objectives and NorthStar? Are you building a Smart Building as a showcase for attracting clients? Are you building it to make your company more efficient? Are you trying to find a way to capture more data for space utilisation so you can reduce costs? So finding out what it is you're trying to solve for, number one. Number two, having a clear way to know whether or not the building being smart actually did anything. So do you have a way to capture the successes and failures so that you know are you actually doing something? It's too easy to, I think, call something smart nowadays. Not knowing whether or not it is, is the tricky part, so trying to figure that out. And then three, I think in order to be smart, you probably need to think about bringing people in from both facilities, engineering, architecture, maybe doing, again, with design thinking people that are not even in the building space but are in experiences spaces, and then bring in some of the potential tenants. Live a life in their day and do a lot of ethnographic studying to understand. But I think that's where we're heading, and I appreciate that that's the work you're working toward.

Matthew: A big thank you to Miguel Sosa, Smart City strategist and former director of IoT innovation at Accenture.

Miguel: My pleasure. Take care.

Matthew: Smart hospitals promise ways to make us better faster, and we'll be discussing how in our next podcast with Nolan Rome and Kevin Cassidy.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

11 – Smart Healthcare

Broadcast: 23/05/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewees: Nolan Rome – Head of Healthcare, WSP USA. Kevin Cassidy – Head of Healthcare, WSP Canada.

Kevin: We're creating a tool the same way that a medical equipment manufacturer provides an MRI. It's – the building is a tool. At the end of the day the healthcare is not the building it's the people inside.

Matthew: You're listening to Smart Thinking, a podcast from the WSP. I'm Matthew Marson taking you on a journey into smart buildings. In this episode, we're talking about Smart Healthcare. And joining me on live link from Dallas is Nolan Rome, and from Toronto, Kevin Cassidy. Nolan Rome is the co-chair of our Global Healthcare leadership team with 19 years of experience in healthcare. Nolan was principal on 50% of the LEED Platinum hospitals around the world. In Toronto, Kevin Cassidy is WSP's Canada healthcare lead with 18 years of experience in healthcare. Kevin specialises in public and private market shares. Welcome to both, and Nolan we'll kick off with you. What is a Smart Hospital?

Nolan: A Smart Hospital, for me, is facilities where we're taking a multi-disciplinary approach to let clinicians spend more time being clinicians, interfacing with their patients, and patients interacting with their environment in a way they have control to heal, and be more well, and be more comfortable.

Matthew: Kevin, what's your take on that?

Kevin: I tend to agree with Nolan. What I'd add on top of that is a truly Smart Hospital isn't just the building systems that are involved with it, in the control. It's also taking regular clinical jobs that those clinicians would be doing and finding a way that the building can actually automate those to free up that time that Nolan was speaking about.

Matthew: I will say that in the UK, we seem to be struggling in bridging the gaps between the digital services that the hospital operates on with some of the building automation. Are you seeing more traction in North America?

Nolan: We see a larger demand on the operational side. I think because Kevin and I both work on a fair amount of private hospitals, it's the majority of our market share, especially in the US. They're looking at how you predict those operational outcomes, and that's what, that's what drives bridging that gap between the digitalization side and say the facility, all the way down to the facility operator. I think it's finding a way to make those interfaces effective, and a way to make those interfaces more stream of consciousness so that the staff doesn't have to think as much. It's more automated to get to all the systems, and collect all the data, and then find a way that's useful.

Matthew: And, Kevin, what is the public hospital perspective?

Kevin: Yeah, absolutely. There, there's certainly a drive towards it. A lot of the new hospitals that we're seeing get built here in Canada, there's a strong desire to implement more of that automization. If you talk to the executives at some of these buildings, they realise that using automation and getting those processes in place are actually going to increase the outcomes of their patients. They're going to minimise drug errors. And it's happening -- automated pharmacies are certainly here tracking the products that they deliver through the facility to make sure that the right patient gets the right drugs, absolutely here. The challenge that we definitely find is, how hospitals actually procure these systems and these services. So as you can imagine, in a publicly funded system, we have to make sure that everything is fair, and procured in a fair manner. This is cutting edge technology that not a lot of people do, and every hospital is doing it in a different way. So it's taking some time for the market to adjust, to really figure out how we build these systems in place, because quite often it's a customised solution. It's not something you can just flip through a catalogue and buy.

Matthew: Kevin, I just want to ask you a little bit further about that. How do you see Smart Technology improving the patient experience?

Kevin: Well, there's two very different things: There's patient experience, and then there's patient outcomes. So, you know, improving the patient outcomes, which I suppose is part of the experience, if you can track things, if you can measure things, and you have the data, you can then learn from your mistakes and make the next experience, or the next treatment for a patient, be that much better. So hopefully over time you're learning from the data that the building is able to collect for you so that you can improve the care you're giving. On the patient experience side, it's absolutely limitless in terms of how we can improve that with technology. You know, a really good example, in a paediatric hospital, a child that's in for leukaemia treatment could be spending months in that hospital. You know, can we leverage technologies? If they're from a rural part of the country with a small, close-knit group of friends and they now need to come to a large urban centre where they don't know anybody can be very overwhelming because there could very well be more people in that hospital than there are in the town that they're from. Can we leverage that technology so they can still attend classes remotely? Can they still have that communication? It can be quite isolating when you're away from your home and you've only got one or two family members that have travelled with you. So, you know, leveraging technologies not only to improve the experience and try to normalise as much as possible, what someone's going through and keep those connections, I think can be tremendously, tremendously uplifting to someone that's in the hospital for a long period of time.

Matthew: For sure. And that sounds incredibly exciting.

Nolan: I think that can float the other way too, Kevin. I think as 5G technology and other things, you know the data catches up with the demand, a lot of those people can start to stay home, or telemedicine actually becomes more of a real opportunity for people to be diagnosed, and for people to have conversations with their medical staff without leaving the farm, and without leaving their rural environments, if they're travelling great distances from, that lead to anxiety and lead to things that are, say, the antagonist to wellness.

Matthew: Nolan, what challenges are you seeing from your clients?

Nolan: We're seeing a great deal of challenge around the complexity of our facilities. We're taking a lot of systems and bringing them to, let's say a singular backbone, and putting clinical private networks on top of public accessible networks for patients, and for staff, and for visitors. And the human side of that -- the people that have to maintain those systems over time -- you're also not just bridging those systems into each other, but you're bridging all the people that support those systems, and having them coordinate, and have them communicate in a way that is completely supportive of the end users. So you've got to be able to support and maintain those systems, let's say to create less infection risk, or promoting better Systems Integration so that we can maintain our air handlers better, we can maintain and schedule operating rooms better in a way that the doctors think about it less, the charting nurses think about it less, and it allows them to focus more on the task at hand, which is delivering care, and delivering very intense complex procedures to our patients. I mean those people that can receive the training to maintain those systems, but also giving them a new skill set to actually coordinate, and integrate, and communicate with other people in a way that's totally behind the scenes and supportive.

Matthew: Why would somebody want to work with a consulting engineer for systems integration to deliver some of the outcomes that you've mentioned?

Nolan: We gave a tour to Kaiser Permanente at our Innovation Centre here in Boulder, Colorado, and it really struck us with a simple question that Kaiser posed, which is ‘Why would vendors want to work with engineering firms and design firms on integration? And, you know, they can't sell you anything.’ Our very simple response back was, ‘That's right. We don't sell anything, so we can test things, we can break it, we can help look for outcomes because we're doing what's best for the community, and what's best for our clients, and that doesn't, you know, it's pretty much independent of the brand name that comes on it.’ Because of that there's some times where that's a challenge and we can't sign some of the agreements that people want us to sign for research. But, you know, I think that's a healthy conversation, a healthy push in the community that it's getting a little less commodity based and getting a little less sales-based and starting to really drive some outcomes.

Kevin: Yeah, it's interesting. The number one, from an ethical perspective, the number one duty of an engineer is to protect the public. And I can't think of a better way to do that than to be involved in healthcare design or healthcare projects. So, you know, it might sound a bit altruistic but, you know, it's an altruistic type of thing, and I think you're right Nolan, being able to do that and, you know, work on behalf of our clients to really test things out and see what works and what doesn't, and provide that unbiased advice is really, really important.

Nolan: No, I agree, and healthcare for me, and the reason I've been doing this for 20 years is it keeps striving to be more community based. It starts with a Smart Building. It starts with a Smart Campus. And that bleeds into a greater discussion about what is wellness for a community, what is the outreach, the education, the making people's day to day lives more well, and making their lives smarter? Letting them know more about themselves and how to care for themselves. That's where the solution really happens.

Matthew: It sounds like the future of health care is more than just a building. We've got a little bit of work to do.

One quick question I had for both of you, and Kevin if you could go first, if somebody wanted to make a Smart Building, what would your two top tips be?

Kevin: That term Smart Building, when you actually start to talk to people, it means completely different things to every single person you're going to talk to. And I think the most important thing to do is, from the get-go, start to communicate and actually have that dialogue around what people actually want. What do they want the building to do? If it is a quote/unquote Smart Tool, let's find out how you want it to function, what you want a function, what are the goals you're actually trying to achieve, and use that as the basis to then set up, what you're going to specify technically to make that building work. The number two thing I think you want to talk about right from the get-go is security, confidentiality, and how you're going to deal with sensitive information that you need to make that building work. Because it's all fine and good to say that you've got an end goal that you want to achieve, but if that involves tracking more things and people are in the building, have you had that discussion with the people that you're going to track to make sure you understand the privacy concerns? If you need access to patient data, have you had the conversation on how you're going to secure that patient data so that you can use it in a safe and secure way that isn't going to compromise the individual's private information? Quite often, we found that the goals that you set at the beginning can get derailed later on because no one's thought about how that information is going to be accessed, or how we're going to hold on to it, and haven't had those discussions. So I suppose overriding both of those things, which is maybe number three, is communication and start talking about it right from the beginning.

Matthew: And Nolan, do you have any top tips to add?

Nolan: Yeah, I think I totally agree with both of Kevin's points, and to that third point, I would engage your user base. I think when you're talking about smart buildings, and particularly smart hospitals, you need to reach out to your client base, and the people that are going to be served and benefit from that, aside from just the clinical users. I think that's one of the great things that the NHS does in the UK is it's a requirement of their projects to really have a user champion group that's involved with their large projects. I was on a design committee with Great Ormond Street Hospital, the child advocates, children advocates were actually some of the strongest and smartest voices in the room.

Matthew: A big thank you to Nolan Rome in Dallas, and Kevin Cassidy in Toronto.

Kevin: It was fun. It was a lot of fun.

Matthew: In our next episode, we'll be talking about how you can increase productivity from a Smart Building with Steve Jarvis from Cordless Consultants.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

12 – Measuring Productivity

Broadcast: 30/05/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Steve Jarvis – Director, Cordless Consultants

Steve: We're only at the beginning of people dreaming up endless possibilities and ideas of how they can use their buildings more efficiently.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into smart buildings. In this episode, output matters. We'll be discussing how to measure productivity. Joining me in the studio is the Commercial Director of Cordless Consultants, Steve Jarvis. Steve's 30-year career spans the ICT services, system integration, and consultancy market in both the public and private sectors. Today he manages commercial presence and growth to help deliver holistic IT, AV, and communications consultancy from strategy to delivery and ongoing support. Welcome, Steve. And the first question for you is: In your view, what is a Smart Building, and how can it help clients?

Steve: Well from a productivity perspective, Matthew, I think measuring the productivity of your staff and business has always been one of the major challenges of many organisations. I think there's plenty of evidence to show that people perform better if they have the right space to work or to do the work they're undertaking, whether that be private focused activity, teamwork, or presentation spaces, always with their own access to the right information and data at all times. Smart and intelligent buildings are enhancing and supporting the demand of users in these spaces.

Matthew: And do you think that's why there's now such a focus on productivity in the built environment?

Steve: Absolutely. We know that there are hours of time wasted travelling between sites, and things like BT have obviously been interested in that for years. But also, you know, going into meeting rooms -- the tech, the people using a meeting space. We recently measured this for a particular client who, on average, spent 15 minutes getting the IT and the AV working in each meeting room before a meeting.

Matthew: Wow.

Steve: When they have over 900 meetings a month, that's a pretty, yeah, a pretty big drain on their productivity. The workplace is no longer just a simple container for your business and your workforce. Workspace now is expected to be designed. It has to be desirable. It has to be experiential. It really becomes a destination where it's a community space that, you know, it attracts your talent, inspires your people, accommodates flexibility, and offers the best amenities and services all on tap. And plus, we want our workforce to be sustainable, and clever enough to sense how they're going to use the space, and automate tasks, automate management of the user experience, all of it whilst adding income to the bottom line. And, you know, that said, we know as a fact that in London a 10% saving of space in a 500-person building is worth around about 1.5 million pound a year.

Matthew: Exactly. It almost seems as if the office has now become a bit of a destination, if you like or, you know, it's the home of collaboration. So do you think there's a way that we could design our spaces to help influence productivity?

Steve: Absolutely. I think, you know, we're very much now talking about the digital user experience, and where people are connected to the space they actually operate in. You turn up at a workplace and your device automatically connects. You don't need keys. You don't need money, you know, to access the services you use in a building. You're greeted by a far softer security system, often using facial recognition. You're given customised messaging, branding, people finding, and way find, as we've heard in a previous podcast. But the coffee machine knows, you know, how you like your coffee, and the meeting rooms knows how you like your heating and lighting. Everything can be easily accessed, controlled through an app, through smart tech, or even your voice.

Matthew: Beyond the technology, do you think there are physical interventions that people can do? Perhaps it's certain types of work settings, etcetera?

Steve: Completely. The concept of activity-based and agile working, about adapting the type of space for the type of role being performed is something we're seeing. It's becoming commonplace in most headquarter buildings and office buildings today.

Matthew: I'm really starting to believe that you can't do activity-based working without some of the tech that you mentioned.

Steve: Completely. The two go hand in hand. You have to be considering the tech right from the outset of these projects. We've seen many people, you know, trying to adopt an agile based environment but the technologies inhibited it, and not supported it.

Matthew: So, do you think there is an accepted way of measuring productivity?

Steve: If you can't measure it you can't manage it, and absolutely in an output-based world being productive increasingly means having access to the right information at the right time, all at your fingertips. And measuring productivity increasingly focuses on pretty granular data and information that reports on the elements that your business needs to be focused on.

Matthew: And how do you see the role of technology in helping us to improve our productivity?

Steve: Technology equals change, and it's been long been said that people resist imposing change. Well that really begs the question: Should these types of people even be working for you today? As a consultancy, we've seen so many times a technology sits there lying dormant in an organisation because people don't know how to use it. Basically people vote with their feet. Opting for tech will offer peace of mind and anticipate their needs. So your people need to use tech to find a way to work or leave if they can't. So don't invest in tech for tech's sake. Involve your users in the tech research. Involve them in the tech design, and the tech decision-making. Employing expensive change managers at the end of the broad placed technology programme is locking the stable door after the horse has bolted.

Matthew: I couldn't agree more. And it's almost important, I think, why you would get them involved as part of that process is because productivity is different for everyone, maybe every department. So, you know, in a bank kind of transaction clearing center it might be the number of transactions you can clear in an hour. Whereas, let's say you work in an innovation function. It could be the amount of patents that you file in a year, or something.

Steve: Exactly.

Matthew: And obviously there's lots of different tools to help you do that.

Steve: And it's more and more measured. I mean and we've got one or two clients who are trying to measure the amount of interactions and collaboration their staff have on a daily basis.

Matthew: Exactly. I was working with the CEO of an investment bank who basically wanted to see if collaboration was proportional to the output of their team, because he just really hated the idea that he was paying for a space for people to be in where they would sit and email each other when they could just get up and have a conversation.

Steve: Completely, yes. And, you know, people that Marissa Mayer, who are making all their staff come back and work in the office because that's where the good ideas come from.

Matthew: That's probably why IBM, which is I suppose the home of the telecommuting employee, sort of said, 'Guys, you need to come back to the office.'

Steve: Completely. I totally agree with that.

Matthew: But do you think, with all this measurement of productivity, that we might be taking it too far?

Steve: Well, I think it's fair to say that in this digital age pretty much anything is possible. The emergence of Artificial Intelligence is allowing so many more options to be considered. But I think it's pretty key to make sure you're answering the right questions about what you really need, as opposed to what you might want or what could be possible.

Matthew: So with that in mind, what would your top tips be for those looking to improve the productivity of their organisation?

Steve: I think there are three key tips here in terms of making an organisation more productive. First of all, understanding what data is available, and learn how to manage it and use it. I think we'll certainly see, yeah, over the next sort of 10, 15 years the amount of data scientists and data analytical people working on those issues is going to boom. The amount of available data is just -- it's just multiplying exponentially at this present moment in time. I think the second thing is really engaging with your staff. A recent Gallup poll showed that 70% of US workers were not psychologically connected to their employee. Everyone has a voice these days, and an avenue to share their opinions, both internally and externally. Smart systems gather data, elicit feedback and can take the pulse of your people and your business. Ignore that at your peril. The war for talent is increasing.

Matthew: I couldn't agree more.

Steve: And finally, make it social. Your workplace strategy, the design of your spaces, and the enabling smart technologies must be considered holistically. Great social spaces, excellent coffee and food enhance the way your people interact and share information. The best businesses embrace this philosophy.

Matthew: Okay, that's really interesting. Have you got an example of how a client has been successful in using technology to deliver more?

Steve: I think fairly well known is The Edge in Amsterdam with over 40,000 sensors in their office, which detect movement of people through the building, and the resulting data is used to better manage their working environment. That's made the application into the organisation increase four-fold, and absenteeism is down by 60%. Also you have the Hive in Paris. They have halved their energy consumption in three years, and the data they've gathered on occupancy, as well as the process of continuous feedback from staff, has ensured they can respond quickly to the views of their workplace, based on hard data and evidence.

Matthew: So there's lots going on out there. We've got the technology in place; we just need organisations to get onboard and consider what's right for them.

Steve: And think about it from the beginning.

Matthew: Yeah. Thank you very much. A big thank you to Steve Jarvis, Commercial Director from Cordless Consultants.

Steve: Thank you, Matthew.

Matthew: In the next podcast, Evelyn Hogan from Cordless Consultants will be guiding the way, as we talk about Location Services.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

13 – Location Services

Broadcast: 06/06/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Evelyn Hogan – Specialist, Cordless Consultants

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into smart buildings. In this episode, we're talking in three dimensions, and learning all about Location Services. Joining me in the studio is Evelyn Hogan from Cordless Consultants. With over 15 years experience operating large scale property operations, Evelyn is now a workplace specialist managing new business development at Cordless Consultants. For me location services are about providing a mesh of connectivity, be that through Bluetooth, or something called RFID, or perhaps even Wi Fi triangulation that helps people find places, things, people, and skills, easily. Evelyn, can you help me make this even more simple? For you, what are Location Services?

Evelyn: Right, so Location Services are technology offerings that are delivered based on size, shape, location of people, or assets in a physical space.

Matthew: And how do you think it can help clients?

Evelyn: Well property costs are the second highest cost in any business, and most businesses want to ensure they get return on investment. So, productivity, staff, so that's why.

Matthew: It's time for them to really sit up and listen.

Evelyn: Yeah, they have to look at it all and look at what they're spending, and versus what the future is going to be with tech.

Matthew: What kind of value can Location Services provide someone in a building?

Evelyn: Value that Location Services can add to a building is to ask individual questions such as: Who's in, where the person is, or an asset, and how do you find them? Is the restaurant busy?

Matthew: That would be really useful because particularly how people are moving to agile working, if you don't know where someone's sat, they become really difficult to try and find. So if we think technically on how you do that, what kind of technology have you seen being used out there?

Evelyn: So, you see a lot now being installed into buildings such as Wi Fi analytics, Bluetooth, reverse Bluetooth, Location Services, that uses a range from people tracking, wayfinding, again, analytic usage.

Matthew: That's really cool. So what I've seen from some of the stats on this is that Wi Fi analytics will give you kind of to the nearest five metres, normal Bluetooth will give you kind of three metres, and then on the sort of far end, the most expensive for reverse Bluetooth is about one metre, which is really good when you have to find high value assets. So I think it's really exciting that we're now starting to provide some locations inside buildings.

Evelyn: It is, and it's giving people that are running those buildings more of an opportunity to see that the building is working, and is it working correctly.

Matthew: Exactly. How are you seeing the transformation take place in our buildings, then, with using this sort of technology?

Evelyn: So personal devices, for instance, mobile phones, they can interact with the building, knowing that the visitor has arrived, what they look like, so they'll do facial recognition, guiding them to the next meeting, telling them who's in today, maybe where they are, and what's available, what spaces are available. Personal automated preferences, depending on your location, setting up your VC automatically based on your preferences, adjusting light and temperature in the room from your device. That can all be done from your phone, or iPad. You don't have to wait for someone in reception to do it all for you. It can now be done yourself.

Matthew: So the building will respond to me?

Evelyn: Absolutely. It will know you already, either be facial or you login as soon as you come into the building.

Matthew: And I suppose because everybody's kind of carrying their mobile phone with them the whole time, it seems to be the best way to pick up their location and where they are. We're in their pockets as such.

Evelyn: Absolutely. Obviously then, the increased efficiency in the building, service performance, which of course everyone wants, reduced power, reduced total space, reducing maintenance and FM costs.

Matthew: Is that because they know where I've been?

Evelyn: It is. They're able to look at the usage in that space, and it's able to tell you where people have been. So, do we need this much space? Can we cut it down? The next building, what have we learned from this building -- what we can do next. An example, which is great one, you know, washrooms. If you get told how many times they've been used, you can contract your cleaning services to work around that usage.

Matthew: What I've seen actually is a big thing that helps you to understand how the customer satisfaction at an airport is. It's normally pretty highly linked to the cleanliness of the toilets, so having this sort of tech implemented there will make sure that your airport is thoroughly loved.

Evelyn: Fabulously done.

Matthew: A question for you. If you were going to advise a client on deploying Location Services, what would the top tips be?

Evelyn: Top tips -- two top tips for today, I would say is fully understanding your primary objective, mindful of GDP or, and all else associated with data protection. It's a big thing. People, some people are quite okay with knowing where you're moving and some people aren't, so that's quite a big thing with some users. Again, as I was just saying, if the users agree to share their personal data, then Location Services will not fulfill its objective. Again, it's how the company and the business sells it. You know, it's a name , your employer number, fine, not your whole back end data, where you live, address and all the other good stuff. Develop your visions and align them with the workplace strategy from the outset, as well as agreeing with budgets very early. Don't leave it last minute to decide what tech you want into your space. It must be first. It can't be left last anymore, because it's what's gonna keep people there. It's what's gonna run the building. So it's first and foremost: Think tech first.

Matthew: Exactly. What I've seen some companies do, that are really worried about the data privacy aspects of this, is to get the staff to almost sign-up to it in the first place. So I think there's an investment manager in London that actually rewards their stuff by giving them a free coffee every week if they are part of the location services data stream. And one of the ones that I was working on, a building in Dublin, we actually kind of made it a cool factor. It's like: Do you really want to be an analog person and not be part of the system? The deal is, if you're in it, and you're contributing to it then you can also take from it. So it became a bit of a sort of prestige thing for people.

Evelyn: Fantastic. That's a good tip. Another tip for the day.

Matthew: Exactly. And could you give me an example of a client where they've used Location Services to their business advantage?

Evelyn: UBS.

Matthew: Okay. What have they done?

Evelyn: They've used location-based services in their new HQ with interactive displays on each floor plate showing locations of people -- where they are -- as well as availability of spaces.

Matthew: And what does that do for their staff?

Evelyn: Well, it's, it's a quite big office. So for their staff, they've got lots of visitors coming in and out all the time. It tells the visitors where they need to go, and where they need to meet people. Vice versa it then tells people what meeting rooms are available, what desk space is available, and where they are based in the office.

Matthew: I remember a report being created from one of my clients that was looking at how they could use Location Services, and from the small part of user testing that they did, they thought they could address 15% of their productivity leakage, which the the facility manager says is about two hours a day. So if you're thinking you can start to chip away at that 15% of the two hours, it seems like there's a big prize available on the table.

Evelyn: Yeah, loads of time saving straightaway.

Matthew: The proof will be in the pudding.

Evelyn: Absolutely.

Matthew: A big thank you to Evelyn Hogan who's joining me in the studio in London.

Next time, wellness just got digital, and we'll be discussing that with Harry Knibb.

If something in this episode has piqued your interest, then have a chat with us. Email Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

14 – Digital Wellness

Broadcast: 13/06/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Harry Knibb – Development Director, Oxford Properties

Harry: I'm interested in smart, healthy buildings, simply because I think they've got a fantastic opportunity to make us happy.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into smart buildings. In this episode we'll explore wellness and how it links to smart buildings. Harry is a sustainability and wellbeing expert who has led a citywide sustainability roadmap for Jakarta in Indonesia on behalf of the World Bank, as well as being the sustainability lead for a number of new town developments in the UK, and the lead author of WSP's healthy buildings toolkit. He's also an award winner for his research into the linkages between pro-environmental behaviour and happiness. We've brought him into the studio today to discuss smart buildings and wellness. Harry, welcome.

Harry: Hi, Matt.

Matthew: So to start with, how would you describe a Smart Building, and why do you think people should invest in them?

Harry: A smart, healthy building is one that has far more controls in it, and more centred around us, as users. So we see more control around things like temperature, like light. More displays so that occupants can make their own decisions about when, for example, to open windows, depending on the quality of the air outside, or the amount of co2 on the inside, for example. But on top of that, there are also more automated systems such as in the lighting. You can look for circadian lighting.

Matthew: I don't know what that is. What is circadian lighting?

Harry: It's lighting that's more in tune with your 24-hour body clock. So naturally the sun comes up in the morning, it's brightest during midday-ish, and then it wanes in the afternoon and the evening. And what we want to see is lighting that mimics that.

The worst thing to do is have blue lighting, say, for your phone, your tablet, you looking at that just before you go to bed, because that's going to wake you up. What you want to see is some red hues in the light. So your building, a Smart Building would integrate those sorts of technologies. But then I think also more widely, especially in terms of wellness, the thing is to understand it in a wider field than the building itself. So you can look at how the building can optimise or enhance your activity opportunities. So technologies like StepJockey, where you can track the steps that you take up and down the building, for example, or smart barcodes on food. If there's a cafe in the building as well, you understand what you're eating and the impact that's going to have on your health, as well as reducing stress in terms of organisation. So what desks you go to, or meeting rooms and factors like that.

Matthew: Okay, so we're talking about a lot of integration for building technology systems, and also more peripheral services. So, why would people want to invest in that sort of thing?

Harry: So I think the business case around smart buildings is actually one of the key drivers that we can see fairly well proven in the research at the moment. I think that, you know, uptake is a different question, but in terms of why you'd ant to do it, first off, I would say it's about the people. So it's about attracting and retaining talent. The workforce these days is fairly mobile, highly mobile in some instances, and businesses use their office as a means for competitive advantage.

The other piece of course is around productivity and profit. If you can have a healthy, productive workforce you're going to be driving more profit out of the people within your organisation.

And then the final thing is, if you're a developer, for example, looking to a build commercial office and sell it speculatively, then a wellbeing strategy that's based around Smart technologies can be a real differentiator in the marketplace

Matthew: Understood. You've noticed from a lot of the client conversations, that we've been having certainly, that health and wellness is becoming increasingly top of the agenda. And what do you think has been the main driver for that?

Harry: Yeah, it's interesting to reflect on that, because I think the biggest driver of it has to be the business case. It's all about productivity, but through people's wellbeing. So it's kind of like a win win. You know, the business, it becomes a better business, it makes more money, but then also the employees have a nicer working environment, so you get to win on both fronts there in terms of the employees and the business. It has been slowly rising up the agenda I think over the last 5, 6, 7 years. I'd like to see it moving quicker, obviously. I feel like, as somebody working in this environment, that the last year or so it's really taken a step forward, which is fantastic.

Matthew: From some of the conferences that I have attended, they seem to attribute the growth and interest in health and well being to millennials. Now I'm not strictly sure that that's true. I don't think it's only young people that want to be healthy. Surely the older generations get something out of it as well.

Harry: Yeah, I wouldn't attribute it to millennials. I think there is a tendency to think that millennials coming into our workplace is going to change everything but, you know, the amount of people who aren't millennials in our workplace still is more in terms of numbers than the millennials in our workplace, I believe, so their influence is still going to be great, you know? And I don't think you'll find many people not wanting a healthy workplace. I think it's just one of those intuitive things. It's another factor that we find when we talk about wellbeing is it's actually quite intuitive to people, of course. It's something everybody seems to want. There are different elements of it. And I think it's quite clear and structured in some of the assessment methodologies, which helps it become tangible, actually,

Matthew: And what are those assessment methodologies?

Harry: So the two most prevalent, are the WELL Building standard, and the other one is Fitwel, which is gaining traction, I think. Both of them developed in the US and, by different organisations. Fitwel was developed by a department of the government, and the WELL Building Standard was being developed by a business. So these all have different drivers in that respect, and prices associated with them, and actually debts of involvement, as well. So, you know, depending on what you're after, one standard could be more applicable than the other.

Matthew: Have you got any examples of where you would go for one instead of the other?

Harry: Yeah. So, a Grade A new build office would be more focused I think on the WELL Building Standard. It's designed for that. A project that WSP is working on is 22 Bishopsgate. That is going with the WELL Building Standard. And that's like an iconic central London office development. It works really well for that.

And we also do a lot of work with asset managers and, who have portfolios of buildings. And if you're looking to do a wellbeing strategy across multiple buildings, actually Fitwel provides a really good framework for that. And it sort of helps you identify the factors that are going to have the biggest influence on somebody's...well a number of people's well being. So it does work quite well for that.

Matthew: My understanding is that we are drinking our own champagne, and we will be doing the Fitwel Standard in our own Birmingham and Manchester offices. Is that right?

Harry: We certainly are drinking our own champagne. Yeah, we're going for Fitwel certification for Manchester and Birmingham. And we're mostly about halfway along the process, I'd say. We're doing a pretty good job actually. We've got some really good well strategies in place, and we're looking to optimise those further in the coming months. And maybe there could be a chance for involvement in some Smart systems as well that monitor air quality, for example.

Matthew: So let's say, I'm starting a new project and I wanted to achieve one of these standards. What are Harry's top tips for a Healthy building?

Harry: The first one is: Consider it from the outset. So, the site location of your building will have a huge impact on the wellbeing of that building for its occupants, which is quite a mouthful. But what I'm trying to say there is that actually there's a health dividend of being in the city than being out of the city.

Matthew: Really? That seems counterintuitive.

Harry: It doesn't, doesn't it, yeah, but actually if you think about it, if you live in a city, you're more likely to take public transport, or walk or cycle to work. If you live out in the countryside, you're more likely to drive. And a real problem in wellbeing at the moment is the rise of lifestyle diseases so, you know the diseases that you attract because of the lifestyle that you live. So if you aren't very active because you drive to your office, you then sit at a desk, and then you drive home again, that's causing problems. Whereas, in a city, you'll be more likely to, as I say, use active transportation methods. You're closer to the doctor's surgery, if you need it. You're probably more socially active as well, so that links into your mental health side of things. But also, you've got far greater opportunity for squash, for healthy food options, for rock climbing, if that's your, what you want to do. So, yeah, I think that there is definitely a healthy...health dividend for cities. There is also, obviously, major factors that need to be addressed in cities like air quality, that still do sort of impact you.

Matthew: So, how do you think that smart innovations and metrics have enabled tangible results?

Harry: So I think, obviously, what I said earlier was that one of the major drivers for health and wellbeing is productivity. That links into profitability. And I think the metrics that sit behind some of this are trying to make productivity tangible, and that's where I think that sort of nexus can work. So, whether you've got less absenteeism because you got a healthy office, or you have more profit made, more turnover made per hour worked, you can start tracking all these things on metrics. And that tangibility, I think, is the thing that really businesses want, so they can understand what their productivity is, pre-imposed interventions, for example. So, if you were to put in a central staircase between two floors, you can start tracking these metrics to see what impact that's going to have before, then after it, which is really good.

I think the other thing is that these WELL and Fitwel, they are metrics in their own right. They are frameworks for assessing the well being of offices. And I think having standards is really useful for people, developers especially, to start to talk about the wellbeing benefits of their offices. It's obviously a very big topic, and without the frameworks in place, then you can end up with, say, one office talking about enhancements to daylight, another office talking about fantastic water quality, but as a purchaser, you'll be very hard pushed to sort of compare the two. But now you've got these standards that have come out, you can start to see well, one, this office here has got a World Gold standard, for example, and this one over here has got a Silver, therefore, what I'm going to conclude is that this is the healthier office.

Matthew: Do you think we'll see a future where property developers will be able to use WELL, and Fitwel as a strategic differentiator, particularly in charging more for leases?

Harry: Yeah, I think we're actually there, to be honest. Not...I wouldn't say it's, you know, mainstream offices everywhere. I think there's a certain band of high-quality offices in central City locations that do use it as a differentiator. And there's research out there from some of the agencies that find landlords can lease offices for higher rates, around 28%, I think, is research of landlords found that they could lease their officers for higher rates if they've implemented a well being strategy.

But but it's not just about high rates, actually. It's about shorter voids, as well. So the offices when they stand vacant, for example, not being vacant for so long. But then, also, again, it's a highly competitive market if you're a developer too. And having some differentiator around wellness is proving to be quite a strong attraction for tenants. So one of the things we're seeing in developers, especially, is becoming sort of what they call 'Well ready'. So they align themselves with these standards. They don't necessarily go for it and seek full certification, for example, the core and shell of a building. But say a tenant was to move into that building. They wouldn't have any trouble becoming certified if they wanted to.

Matthew: From some of the things that you were telling us before, it seems there's a big expectation to kind of prove that health and well being isn't that fluffy business case that we had in the past. So could you tell me a little bit about Systems Integration, and how we might be using that to prove some of these business cases?

Harry: Yeah. There's a few things around Systems Integration, I think, that can help those sorts of things. It's quite a sad story actually, but the...there's been a lot of press, you know, just sort of zooming out a bit, the national press in the UK, especially around the impacts of air quality on our health. And tragically there was a girl's death a few months ago. And the times that she went into hospital correlated really strongly, strikingly strongly, to days where the London air quality was excessively high. And it's those sorts of correlations that are, you know helping people to realise actually these environmental factors do have a huge impact on our experiences, and on our health. And then that health does have a huge impact on our economic performance as well. So for example, one of the, one of the linkages you could make is quantum of co2 in an office to number of sick days stored on your sort of central data management system, obviously other sort of wider considerations like that.

Matthew: Exactly. I've seen quite an increasing number of clients that are bridging the gap between their Enterprise Resource Planning software, or ERP, with their Internet of Things platform, and they're doing exactly that. They're tying in some of their normal kind of attendance and absenteeism metrics with the actual physical qualities of the space. It's a really interesting time.

In our next episode, we'll be talking with an ethicist called Conor Clarke, who will be telling us why ethics is more important than ever in a world of machine-based decision making.

If something in this episode has piqued your interest, then have a chat with us. Email Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

15 – Ethics

Broadcast: 20/06/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Conor Clarke - Consultant, Accenture, MA Philosophy (Cantab), PhD Candidate Birkbeck, University of London.

Conor: I think ethics is always there. It's just not always a very thoughtful or reflective ethics.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into Smart buildings. In this podcast, we're talking about how ethics are more important than ever in a world of machines making decisions. Joining me in the studio is Conor Clarke, innovation and technology professional who helps his clients to design and build technology solutions to solve problems across the organisation. Conor holds philosophy and ethics degrees from the University of Cambridge, and King's College London. Welcome, Conor. And jumping in straight to our first question: What is a Smart Building, and why should we care?

Conor: So I would imagine different people have different answers to these questions, and different professionals care about different things, but for me, as somebody who's interested mostly in the philosophy and ethics angle, I think what a Smart Building is, fundamentally, is a building that can make decisions, that can make choices about the environment. And those choices might have ethical dimensions to them.

Matthew: Could you give us a couple of examples?

Conor: So, you know very well that my favourite example of Smart building technology is the democratic thermostat. So one sort of pre-existing puzzle in political philosophy is the idea of the persistent minority in democratic politics. So, if we endorse democracy as an ethical decision making process for communities, for populations, but we also have certain sort of subgroups within that population who are consistently finding themselves in the minority in the course of the democratic decision making process, what do we think our ethical obligations are to those persistent minorities, given that they will very rarely if ever get their way? This is the kind of ethical question, which it would be very easy to overlook in the design of a feature such as a democratic thermostat if you didn't have your ethical cap on when you were trying to make these decisions, when you were designing the mechanisms that allow these buildings to make choices. But there's a very rich tradition of ethical thought that could be used to inform those decision-making processes, your design of these control systems, which will potentially make your building more ethical.

Matthew: So you're saying that when we are making systems that have to make some kind of a decision, we have to be thinking about those that might be worst off from the decision that the machine makes?

Conor: Yeah. I mean I think there's already comparable ideas, or responsibilities, at play in the built environment, so you will know from your training that architects have a certain kind of legal, or fiduciary, responsibility to design buildings that are going to behave in predictable ways. I think there's a similar obligation for the people who are designing the decision-making procedures for buildings that do more than just exist as part of the built environment and provide space for you to sort of exist and work in. I think that there's a comparable responsibility to design robust buildings that are robust, not just structurally but also ethically. And I think the designers undertake a certain responsibility when they decide they want to do that, when they decide they want to make a Smart Building.

Matthew: That's incredibly interesting. I'm certainly seeing movements in the market with a growing interest in ethical Artificial Intelligence.

Conor: Yes.

Matthew: And how to kind of build-in the right thing to do, which is incredibly difficult to define. So would you think it's fair to say that ethics are more important now than ever?

Conor: I think so, and to substantiate my point I'm going to quote Spider Man. So, 'with great power comes great responsibility' is a fantastic pop cultural slogan of ethics, but it's also, I think, a fairly substantive statement and probably true. So as we gain more capabilities as human beings, as we advance our technology, as we gain the technological know how that allows us to do new things, we have to also consider how those new things are going to impact our ethical frameworks, are going to what relationship they're going to have with the things that we value, what the impacts, or consequences, or fundamental character of those decisions are going to be. And aside from anything else, the potential to use these new technologies usually means we're creating new and interesting ways, potentially disastrous ways, for things to go wrong.

You might have seen in the news recently on the BBC, I know there was an article about the police using big data algorithms. I'm not sure if it crosses the threshold into AI, but certainly Smart Technology, to identify within a crowd suspects for further examination by trained police officers. Now obviously this set everyone's sort of Orwellian bells ringing. People were very concerned about computers profiling suspects, or making decisions on criminality, or the sort of suspiciousness of individuals in a crowd. But I think this is a prime example where just the ability to do something that we couldn't do before -- train an automatic system to look at a large population of people and pick out people who resemble known criminals, or people who look suspicious, or hit certain markers -- raises a whole set of ethical questions that maybe were always implicit in ethics, but which never really came up before because we just didn't have the capabilities that were relevant to make them worth considering.

Matthew: And it's almost as if the pursuit of productivity allows us to kind of get away with things that we might not consider as ethical in an analogue way. So if you were to take an understanding of how people like their temperatures, for instance, or even the sort of work setting that they might use within the office, it might lead you to deduce certain indicators about how well they perform, or particular behavioural characteristics that they have. And in doing so you could lead somebody to make hiring decisions on the basis of say something something simple like: Do you prefer it warm or cold in the office? And I think where it's a bit of a slippery slope.

Conor: I think that's a very good point. Anybody who's been paying attention to what's been going on Amazon recently knows, and indeed anybody who's been paying attention to industry in general for the last since about the 1920s, will know that Taylorism, this drive to treat people more like elements of a machine rather than as sort of human beings with needs, desires and, you know, limitations and stresses all of their own, will be aware that it's very easy when you start reducing every dimension of your organisation to data points, it's very easy to lose sight of what those data points represent. And that leads to things like, you know, Amazon workers, who are carrying out picking tasks in their warehouses, being afraid to take toilet breaks, because they're afraid it will impact the data which their supervisors are using to track their performance, and draw conclusions about how good they are at their job. So, I think, yeah, the capabilities can often obscure the rights and wrongs of what it is that we're trying to do because people get so caught up in the enthusiasm of the productivity gains, or of the potential that that new technology represents. It's very easily done, and very easily done especially in an environment that tends to emphasise compliance, and legalistic considerations, as opposed to more fundamental deep dives, if you want, on consideration of the underlying ethical issues. I think that's something that's...I think compliance and ethics are different things and they're very often sort of conflated and drawn together. So that's something to watch out for as well.

Matthew: In retail, we're seeing there's a kind of pushback for the use of technology in automated tools to say offer you a particular offer, and even when it becomes overly personalised to you, there's almost like a, it's gone a little bit too creepy. But these are really important metrics for investment decisions in the marketing campaigns of these retailers. So how do we find the right line between doing what's right for our business versus what feels right to the population?

Conor: I think what you might be alluding to there is the much-publicised case of the lady who didn't realise she was pregnant, but then started to receive recommendations for nappies, and formula and things like that.

Matthew: That is one example, yeah, yeah.

Conor: That is one example. And I think that the...and that is creepy, obviously. And that puts people on edge for perfectly understandable reasons. I think that the balance that you alluded to that we need to strike comes from not cutting, A, not cutting human beings out of the process. If you're considering doing something that becomes fully automated, then you have to have a robust considered human approach to designing that process which takes into account all the relevant factors. You can't just optimise based on data. You can't just optimize for productivity because you will inevitably encounter, at least in my opinion, you will inevitably encounter unexpected side effects of doing so.

Secondly, if you can keep humans involved in the process, I think, and it's desirable to do so, I think that's definitely a beneficial thing. Machines are nowhere near the ability to replace a human being's considered ethical judgement. So if you can get somebody involved in the decision making process who is capable of wearing that ethics hat, who could bring that kind of judgement to bear on the situation, I think that's a very useful safeguard, or check and balance to have placed on this technology, just to make sure it's sort of serving the kind of values and ends that we do think are important, that we do, you know, find valuable.

But also, even, and this is a broader point, it doesn't necessarily apply just to Smart buildings, but I think it does apply to Smart buildings as well, getting people who have thought deeply about ethical issues, who have training in the traditions of ethical thought that we have access to but tend not to utilise, is very important to getting to the right answer on all of these sorts of questions, because you don't have to start from scratch. There's thousands of years of tradition, and ethical thoughts, and ethical discussion, and you know rational, logical attempts to sort of get to the truth, the heart of the matter of what the right thing to do is. So why not use that resource?

Matthew: Would you go as far as saying that any machine that is capable of making decisions should be required to have a human supervisor?

Conor: I think that's pretty plausible. I think if they don't have a human supervisor, someone needs to have been involved in the design of that system who at least is capable of bringing this lens to the question. I don't think that it's...I think it's reckless to design systems like this where you're simply optimising for performance metrics, because I think that's courting disaster. I think if not involved in the actual process, it's very desirable to involve someone like an ethicist, or someone who's engaged with these issues in a substantive way, in either design, or the actual process that's considered here.

Matthew: What would your top tips be to somebody who wanted to design an ethical Smart building?

Conor: Hire an ethicist. And any kind of practical steps beyond just hiring an ethicist? Yeah, so, hire an ethicist. They don't have to steer the conversation. They don't have to make sort of big deterministic decisions about what it is that you do, but involve them in the design process. It's very much *de rigueur* these days to have co-creation processes to bring in cross-functional expertise, to enhance the quality of the designs that you're...that you're producing. You would never dream of designing a customer facing product these days without somehow getting the voice of the customer involved in that, whether that's a data driven exercise or more of a qualitative exercise. There is absolutely no reason why the ethicist's point of view shouldn't also be an input into that cross-functional, collaborative design process.

Matthew: A big thank you to Conor Clarke, innovation and technology professional for joining me in the studio.

Join us in our next episode where we'll be turning the tables on myself with a guest host. Tom Smith joins us, who is the global director of property and buildings, as he quizzes me on the drivers for strategic value within a Smart building.

If something in this episode has piqued your interest, then have a chat with us. Email Smart@WSP.com. You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

16 – Drivers for Strategic Value

Broadcast: 27/06/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Tom Smith – Global Director, Property & Buildings, WSP

Matthew: In this podcast, Tom Smith joins us, who is the global director of property and buildings, as he quizzes me on the drivers for strategic value within a Smart Building.

Tom: You're listening to Smart Thinking, a podcast by WSP. I'm Tom Smith, guest host for this episode, where we'll delve into the drivers of strategic value, as I quiz your usual host, Matt Marson. Matt is the UK and Middle East head of Smart buildings at WSP. Matt focuses on designing and delivering digital real estate transformation and human centred IoT technologies within the built environment. Matt was named as the Institute of Mechanical Engineers, Young Visionary in 2016/17 for his work in creating the world's most connected building. He has since spoken around the world on the topic and is an author in the Encyclopaedia of Sustainable Technology for the design of Smart cities.

So Matt, let me kick off with my first question to you. As I travel around the globe meeting our clients, discussions inevitably end up talking about how technology is influencing the design of buildings, precincts, and cities. What do you think are the drivers for the digitization of our built environment? And what are the barriers to deployment?

Matthew: So I think there are five main drivers that our clients are caring about. Firstly, it's experience: The idea that you can build it cheap and sell it for expensive, which is a model that property developers are really used to, isn't quite flying with their customers, and they want to see how places can be more curated particularly through the delivery of some kind of a digital service.

The second one is: Wellness. Given the rise of wearables, and how we're much more concerned about proactive health rather than reactive, we want our spaces to be healthier, and Smart helps to deliver some of that.

Thirdly, it's about sustainability and looking at how we can be kinder to the planet and reduce some of the energy consumption, particularly when we're thinking about cost. Other clients are actually looking at the importance to their brand. The fact that companies, such as Deloitte, who's in The Edge in Amsterdam, which is known as one of the world's Smartest buildings, it's been really important for them to show how they are in fact a digital company themselves.

And finally, I think the fifth one would be around productivity and how that you can use technology to remove obstacles to people's days, that might otherwise have gotten in the way, so they can get on with more work.

But the barriers to deploying some of this stuff is firstly that it's really complicated. It's crossing a lot of boundaries and silos that we're used to in the construction industry. And it means that there's a lot of confusion out there. And here at WSP at least, we're trying to simplify that process for our clients.

Then there's the idea that software companies are really good at making software but don't really understand the built environment very well, and vice versa built environment companies sometimes struggle with software, and we've got to try and bridge that gap.

And finally, I think it's to do with cost, and understanding that although the technology does actually come with a high price tag in some cases, you need to consider the full lifecycle in the costing, and how you might be able to make money out of it, or to reduce your costs.

Tom: And I suppose linked to that, Matthew, you know, I certainly feel that our clients are very concerned that they're not keeping abreast of these new technologies. I think that's a reflection of your earlier comment about the whole arena of Smart being quite complicated and confusing to many clients. So how can we, as WSP, help our clients future proof their buildings, firstly to embrace these new digital technologies? And I think a second point is actually avoid these future technologies becoming obsolescent?

Matthew: That's right and being future ready is difficult. And where I think we're actually being quite successful in some of our designs is considering it as a kit of parts, and thinking in terms of systems, not just point solutions. So because you've got a particular problem today, doesn't mean you're going to have that problem in the future. And we should think about technology, particularly with the speed at which it gets updated, or improves, as something that you can clip in and out of a building in a simple way.

In fact, if you think about your smartphone, I can add a new functionality to it tomorrow by installing a new app. And if we've got the right physical stuff, as we do in a phone, simply by adding a software addition on top, it means that we're able to unlock new capabilities. And we should start to think of buildings in exactly the same way as our phones. Or, perhaps it's investing in something like a platform. And if we think of that as digital glue that can start to tie together different services, or systems, then we can be much more plug and play, and adapt things for the future.

So I encourage our clients really to embrace it, have a go at some pilot, something that's really low capital, just to kind of cut your teeth on the experience of it and start to essentially play around. You'll find what works for you in your context. And then you can start to looking at scaling that up.

Tom: And I think following on from that, I noticed that, you know, much of our focus as designers and project managers is on the actual delivery of buildings, but how can Smart technologies actually improve the overall performance of the buildings, particularly around productivity and outcomes? And I suppose what I'm trying to get at is actually: How can we broaden our service to our clients from being in the design and delivery of buildings into the sort of digital asset management phase?

Matthew: Yeah. Our engineers are smart people, but I think sometimes when we're wrapped up in things that are incredibly technical, we lose the human element. So, I would like to kind of challenge our engineers a little bit more to think more human-centrically, and to be a bit more combinatorial. The fact that you're a specialist in a particular discipline doesn't mean that you can't go talk to the other disciplines, because I bet if you have a chat, you'll find that together you can probably make something that's pretty awesome.

I mean let's take an example. If we want to think about the folks that run our healthcare practice, or even do some of the standards to do with WELL or Fitwel, I'd want to get them talking to some of our building services engineers. Imagine if you could take some of the WELL standard kind of requirements and show that from the machines that the services guys would expect that we're actually reducing sick days. So if we could take that data from the building management system and combine it with people's timesheets, we can start to prove that the design elements that our engineers have come up with are making lasting business impact.

Or, perhaps it's thinking entirely differently about our relationship with a space. We're very good at doing thermal comfort, but we often find that there's a mismatch between the temperatures that people like in a space. So what if actually we start designing buildings such as, you know, the top floor, go if you like it warmer because you're hot stuff, or if you stay on the ground floor, that means you're a cool thing, and just giving people that human touch in being able to choose where they sit means that we can deliver superb engineering services to get that done. And often, I think that sometimes if we don't design in a human-centred way, it feels like there's a lot of barriers to getting stuff done. And what we really need to focus on between us is being brilliant at those basics.

Tom: And what you've just said there resonates with much of my own ethos, because at the end of the day buildings are for people, and if we can have a sort of human-centric approach to our design, then it's going to not only improve the productivity but actually enhance the outcomes of those buildings, and it makes our value proposition much more compelling. Going on to my final question, it's clear that you're a Smart buildings expert, but I'm particularly interested in how you go around collaboration with technology firms, PropTech start-ups, and software partners to co-create an ecosystem that's appropriate for our clients needs?

Matthew: Well, at WSP, we know buildings. We know cities. We know communities, and how to design those pretty well, and we keep abreast of technology. But I think we'd be a little bit arrogant, if we thought we knew everything about technology too. And that's why we need an ecosystem of alliances and partners that can help us close that software and engineering gap that I was talking about earlier. But there's lots of things that we can learn from them and they can learn from us too.

So for instance, I actually had a software company call me up and say, 'Look, we really want to move into the Internet of Things space, because we think that the physical is going to be really important to our software, but I don't feel that I've got the credibility to be able to go design that. Could you teach us more about the built environment, and in return, we'll teach you more about software?' And that works as a really good partnership.

Or, perhaps it's actually looking at one of the issues that one of our clients came to us as well with. They were interested in a tool that could help them with issues in their city, and what to do about them. So we partnered with a technology company where we provided the expertise on the built environment, and they helped translate those into a really robust tool, full of machine learning elements.

And then, if I think about start-ups and some of the kind of smaller companies, if we're honest with ourselves, in the future they could be our competition, or perhaps it's the technologies that we'll have to use, so I kind of want to get involved in that now so we can help accelerate them on their journey, and to make sure that we're always providing the best value for our clients. So it's a really kind of exciting time with everything that's going on in the PropTech world at the minute.

Tom: There's no doubt that digitization is transforming our built environment, and our Smart consulting offer will certainly assist our clients with this transformation.

Matthew: Tom, I've actually got a question for you. On your travels, when you're talking to our clients, what do you think is the kind of biggest worry that they've got about Smart and technology?

Tom: That's a very good question, Matt. I believe that a lot of clients are quite confused about the rapidly changing landscape around digital solutions. And they're looking for partners that can give them independent and authoritative advice. And linked to that is the fact that there are so many different players in the marketplace -- software companies, large technology companies, start-ups -- who are all offering their advice, and it's quite confusing for clients. This reminds me of sustainability probably 20 years ago. Sustainability was a new concept, and it took quite a while for clients to be able to grasp that and understand the value that sustainability can bring to their buildings, and how it can improve the performance of buildings.

So I think there's an important role that we have in articulating how technology can actually help our clients deliver super buildings, and those super buildings aren't going to cost a huge amount of money. They're not going to add increased risk to the schedule. So they're really the main issues I have, and I do sense that the more that we can become a trusted adviser in the smart consulting space, the more that we're going to be able to articulate about the whole package of services that we can bring, and actually the contribution we make, not just in the design and the construction phase, but also in the asset management phase, and the ongoing performance of that asset over many, many years.

Matthew: Agreed. One thing that I'm also interested in is what would your advice be to our engineers to help us get to that place?

Tom: I think I'd be saying to engineers is they have to be much more open to the possibilities that technology brings to buildings. It's not necessarily about the ducts, pipes, wires, columns, and beams. It's about how that building performs, and how occupants, users, colleagues actually feel the space is actually enhancing, not just their wellbeing but actually their health, their productivity and also, that in itself gives them a much better feeling about the company they work for.

So, they're the sort of things that I think are very important. It's important that we open up our mind to the possibilities that technology brings. And I think the other thing is to recognise that actually we have experts within WSP around Smart space that can actually help them. As you alluded to earlier on in this podcast, there's a huge amount of change going on. Technology is advancing at a rapid pace, and I think it can be quite scary for many of our project managers and designers, but with people like yourself, Matt, you can help those engineers. You can help people like me to articulate to build capacity in our offer for our clients.

Matthew: I think we're going to have an exciting couple of years.

In our next episode, we'll be talking about how property developers can use information as a service as part of a new business model. Joining us from Boulder will be Jay Wratten. I'm Matthew Marson, and thanks for listening.

Tom: If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking podcast by WSP. I'm Tom Smith and thank you for listening.

Smart Thinking Podcast

17 – New Business Models for Developers

Broadcast: 04/07/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Jay Wratten – Vice President, WSP USA

Jay: A Smart Building is more than just an app. It's a strategic business tool, both for the building, the community and the portfolio.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into smart buildings. In this episode, we're talking about new business models for developers. And joining me today from Boulder is Jay Wratten, who is a Smart Building strategist at WSP USA, and is one of the leaders at WSP's, BOLD&R Innovation Center, where he challenges clients to think bolder about Smart buildings. Welcome, Jay. And to kick off, we'd like to ask you: What is a Smart Building, and why should we care?

Jay: Why we need to care about a Smart Building is that there's a number of changes in the way people will do business with a Smart Building. We're seeing a demand for Smart buildings. And it's important that the developers recognise this demand and start to serve it. So when we think about Smart buildings, the critical component here is that the building is agile, that it's responsive, that it doesn't do today what it does tomorrow. We're also thinking about buildings that respond to the needs of the tenants going forward, so we've seen a significant change in how tenants use space. And so a Smart Building, in the context of a developer, needs to address the changing model of tenants.

Matthew: And do you think it's only the changes in use of space that's driving the demand that you were talking about?

Jay: Not necessarily. I think that...that's a really good question. I think that change in use is a big aspect, but I think that we could probably put a broader subject around that and say that in commercial real estate, the way businesses do business is changing. If you cast your mind back to 20, 30 years ago, people came to work every day. They had a desk. They interacted with colleagues. And we look at how we're working today and anticipate working in the future, the way we as employees add value to our businesses has changed. We may not be there every day. We may be working globally. And that has a change on the way we build or should have a change on the way we build and operate buildings.

There's also been a significant change in the way we look at Sustainability, the way we look at how our buildings connect to the cities around them. And in that respect, I think a

Smart Building, and the technology that enables that connection, is one of the things that will be a prime focus of real estate going forward.

Matthew: Understood. My opinion on this is that if you think about how digital has fundamentally changed the way in which businesses operate, and you can accept the premise that your building is essentially a container for the set of processes that happen physically, buildings haven't really changed. And I think that's why the tenants are now kind of saying, 'Look, Mr. Landlord, it's time you stepped up and helped respond to some of the changes that my business is going through.' So with that in mind, I'd like to ask how you think technology is shaking up their traditional business model? So that could be, for instance, build it cheap, sell it for a lot. It seems that this isn't kind of enough anymore?

Jay: As you say, it used to be that it was built it cheap, sell it for a lot. When we think about sell, for a number of developers that means rent. And so what we've seen in the tenant model is that tenants are asking for more. And they're expecting more from the building on the digital side. So where the expectation was that the lights turned on, and cool air came out of the vents, and maybe you ran the security down in the lobby, they're now asking questions like: Well, what's my carbon footprint in this building? What is the air quality that is coming out of those vents, and how does it affect my employees? There's a health and wellness discussion.

And they're expecting more infrastructure in the building to support those needs. So, the build it cheap model has changed. And I think we're also seeing a change in the role that developers play in tenant space. So historically the tenant space is a warm shell, right? They just put a box around it and then the tenant builds it out. And that line between developer and tenant is very clearly drawn. We're going into a place where developers have the ability to enable a Smart workplace for the tenants by providing more of what's called 'Smart infrastructure' in their building, and it will enable a different kind of tenant.

Matthew: So you're saying, actually, landlords have more of a role in curating, perhaps not an experience just yet but that's something on the horizon, but more an environment, as opposed to, here you go, here's some space?

Jay: Yes, and I suspect for the developers that may be listening here, almost none of them will have not already thought about co-working space, and whether they should be operating co-working space within their buildings. And I think that that is a paradigm shift in how developers think about their buildings. You know, most of them, when it comes to operations, they may have historically thought about facilities in terms of management, or they may have simply just outsourced that to a company that provides that service. But now suddenly we're seeing a generation of buildings where there are components of the leasable space that are multi-tenant inherently. They are these co-working spaces. And so developers are asking themselves: Do I want to be the operator of that co-working space, because it represents a revenue add over my traditional lessee structure? And so now they're in a totally different space around that.

And I think also, to your point around curating experiences, the idea of shared space within a developer's building has totally changed. So tenants are going to expect maybe there's a fitness centre. Parking is an easy one, right, but you know maybe there is a rooftop Conference Centre that's a shared component of the building. It's operated by the landlord and shared for all tenants uses. And I think a lot of that model comes out of this idea that the sum is greater than the parts, that by being part of a community that is this building, you can engage with the other tenants in a way that is different than what you've done historically. And developers are in a prime position to operate and offer that space where the connection between tenants happens.

Matthew: And I think this change is slowly coming about. I know from some of the work we've done here at WSP with some of our large property developer clients, we've been helping them to understand what their future business strategy could be. And one of the ideas that we keep teasing out is this idea as having information as a service. So one of the things that I'd like to understand from you is: How does an information as a service model work, and what is it, and how do you think a client could benefit?

Jay: Sure. So for a little context, when we think about fill in the blank as a service, and the fundamental difference there is that you're paying for it in an ongoing fashion as opposed to buying something up front and never paying for it again, this is a model that has started to permeate a number of different markets. And I think Pandora is a good example, to just talk about as a service model. So when I grew up, if you wanted music, you went to the store and you bought physical media: You bought a CD, you bought a record, you bought a tape, etc. You owned that. You never paid again to listen. Pandora's model is I don't have to buy anything physical. I just, you know, have a licence to listen to any music I want, right? So that's the 'as a service' model.

When we think about information as a service in the context of a Smart Building, the question then becomes: What is the revenue model and what are you actually selling, right? So a building generates data, and how can a developer create a revenue stream out of the data that they're generating? Our view is that that needs to be a tiered discussion. So data by itself is not very worthwhile. The information, and the analytics, and the decisions that you can derive out of it bring value to that data. And so, we're proposing that developers consider a tiered model where raw data, for example, you know, when people go in and out of the elevator lobby, what is the air quality in the space? What is the energy consumption in the space? Right, the things that they can easily monitor would have low to no value. And it may be that there isn't a revenue model there, that that's just the expectation of tenants that they have access to that data, just like today they have access to their space. But in a tiered model, if the developer were to invest, or pay for some software and analytics over the top of it to turn that data into useful information, they could then sell that as a service. So for example, they might pay...provide information about the arrival density of people in the building and help a tenant within the space understand how their employees come and go. And that is a value add that they could provide as a revenue stream in terms of an information as a service model.

Matthew: Okay. So, do you see a future where, that actually buildings come with a set of analytics and applications to help you understand what happens inside them just as standard?

Jay: Yes. I think that right now we are probably in the sensorification and connecting things phase of large-scale Smart Building rollouts. There's a huge change, as we've talked about, already in the way both developers and tenants are going to use and operate within that context of data. But we're already seeing devices going into buildings that have a little bit of, what we would call, 'edge analytics'. So, think of the box that, I don't know, controls the lights in the building, or controls the air conditioning in the building, that box has a network connection on it, and inside is a little computer, and it's running a little bit of analytics all the time to create that useful information. That information is likely to be free, and just comes as part of a building and accessible. There is a conversation around data ownership and governance of that data, but I think that, that we will see low scale information largely free because of those enabling technologies in the devices going in.

Matthew: If you were a developer, and you wanted to embark on creating an 'information as a service' model that you would monetize, what would your top tips be?

Jay: Well I would start with, you know, what is my client base, and what am I trying to achieve? So we always go back to the why: Why do it? It has to support your business model. Just like we talk about sustainability in that you need sustainable sustainability, people only do sustainability measures if it brings value to their business. And as we think about Smart buildings, it needs to be the same discussion. If I was going to embark on a Smart Building, I would want to make sure that I understood why I was doing things. And that might be my market is seeing a reason to have better air quality. It is in my best interest to differentiate my property by not only creating that better air quality but sharing the information about it, so the tenants understand how my building contributes to a more healthy employee, and therefore brings value to their business. Those are the sort of why statements and drivers, I would say, as to what a developer needs to do to embark into a building. I would say, in terms of what not to do, don't just commission somebody to build an app for your building, and throw a bunch of pretty pictures together that are backed up by no real business need.

Matthew: Really helpful advice there from Jay Wratten, who joins us on Live Link from Boulder, in Colorado.

Join us next time when Peter Richards introduces us to the concept of Cyber Physical, and reveals what a Black Swan event is.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

18 – Security

Broadcast: 11/07/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Peter Richards – Director, WSP Canada

Peter: Smart buildings converge networks. There's no actual threat there until somebody comes at that with a malicious intent.

Peter: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into Smart buildings. In this podcast, we're talking about Cyber Physical Security. Peter Richards is in the studio today to talk through all things security. With 10 years with the UK Counter terrorist team of the British Army, and ASIS physical security professional, a Class 1 data systems engineer, and with an MSc in security risk management, he'll provide us insights into security risk management, and technical security system design. Peter is now head of WSP security risk management division, based in the Middle East. Peter, welcome.

Peter: Hello, Matt.

Matthew: First question for you, Peter, is: What is a Smart Building, and why should we care?

Peter: So, a Smart Building, in my opinion, is a connected building where all of the subsystems, may it be lights, vertical transportation, air conditioning, they're all connected together. And why should we care? Well, buildings are becoming Smart. And with that we are creating, not only a better user experience, but we're creating vulnerabilities, which can be exploited through intention, or just through vulnerabilities, shall we say?

Matthew: At the start of the podcast, we introduced this as Cyber Physical Security. What is that?

Peter: What this means is it's not the theft of data, although that is obviously a big concern to many users. My concern is the physical threat to people, so Cyber Physical would not be the loss of your bank account details, it would be something information-driven that results in a physical harm to somebody. So that could be anything from a vulnerability in the air conditioning system, which leads to a building that becomes unusable just because it's 28 degrees. That's a business continuity issue. And it's something that really results in a physical harm, or an un-usability from a business continuity perspective.

Matthew: So, for instance, if I could hack into a cooling system, I could say heat-up a data center and potentially set it on fire?

Peter: Yeah, of course. I mean, the second there's a problem with an air conditioning system, then you have a dollar value cost with anything that impacts that system. But you could also have a problem with vertical transportation. You know we're in London. If you can't use an elevator, it could quickly become a major problem for a business.

Matthew: So you could track people in a lift, for instance?

Peter: Well, you could just stop the lifts from working. Then you would be in trouble. You know, in a building like The Shard, which is very close to WSP, if the lifts don't work, you're gonna expect somebody to walk 80 floors to the Shangri-La's lobby? No, you're not.

Matthew: It seems that given the promise of the Internet of Things, or IoT, by having kind of digital systems control something in the real world, do you think we're asking for trouble?

Peter: I don't think we're asking for trouble, but we have to just be aware of the risks. And it doesn't have to be the intent of, you know, hackers, and these malicious people. It can just be the Smartness of things creates a vulnerability of things.

Matthew: So what, do you think it could be too Smart for its own good?

Peter: I think it just has to be managed well with some foresight, that's what I would say.

Matthew: So if you were to be designing a Smart Building, and you were considering the security of it, what would your three must have factors be?

Peter: I, being a security professional, I would probably come at it with the 'must have not factors'. And I would say, first of all, Smart is not something that should be considered by the IT department. It should be considered as a holistic approach. The Smartness, the networking, and the physical experience, that is key -- the whole holistic approach. And we in WSP, of course, have engineers in every system. But if you talk to any engineer and ask them about Smartness, or the Internet of Things, they'll think IT. But it's not IT. It's IT wrapped around everything that we do as a company, actually.

Matthew: Understood. There are, it seems, a growing number of high-profile kind of case studies, or examples, of where something's gone wrong. For instance, the company that was hacked through their IoT fish tank, or Target losing three million of its customers' records through a vulnerability in the building management system. Have you got any examples that you can share with us as a warning?

Peter: I have one example which I can and cannot share. It was a client of ours, actually, in the USA. And it was a transportation agency, so a government entity. And they lost their access to their email accounts for one week. You know, that's it. We don't have to discuss it really. If any company loses email for one week, it's a serious issue, of course. But honestly, I really don't think we've seen anything yet, so my expectation is that we're going to have what we call in risk a 'black swan event', which is the event that nobody thought about, but after it's happened it becomes obvious and everyone says, 'Why didn't we think about that? It was a massive incident.'

Matthew: One of the big questions that my clients are always asking me is around security to do with their networks. And when you think about Smart buildings, the big question is: Should I have a converged network, or should I have a separate network? Have you got a view on that?

Peter: Yeah, I have several views on it. It really depends on which region we're talking about. As a consultant, obviously I would advise my clients on the benefits of dedicated or converged. Converged is cheaper. It's faster. It's easier to pull cables -- all of these things we think about as engineers when we design and build these structures. But, yes, of course there's risks. There are risks and redundancies, so we have to think about topology.

In the region I live, Dubai, for instance, all security systems have to be on their own dedicated network to appease the local authorities -- a law called Law 24. And every region, the authorities will have their own stance and posture on whether it should be converged or not. Really, I would say, every project, every building needs to be approached in its own right. And there are benefits for converged and dedicated, but there are also dollar costs to both as well.

Matthew: I just want to go back to an earlier point around Cyber Physical. Don't you think it's quite odd that a traditional engineering company, as how we're considered, is now looking at Cyber Physical Security?

Peter: I don't think it's odd. I think it's forward thinking. And I wouldn't work for a company like WSP if it wasn't forward-thinking. You know, my background is counterterrorism, and really as an ex-soldier, we're talking bullets, and bombs and physical harm, but things have matured, and we're really talking about risk mitigation to our clients. And what are our clients are doing? Well, they are investing in iconic developments, very large structures, and they need the best service they can get in terms of risk mitigation and protection, so.

Matthew: What kind of things are you doing as part of that, then?

Peter: Well, traditionally we would do things, a security risk assessment, which could be anything from identifying the most critical assets that you have. Most building's critical assets are the same: the electricity, the telecommunications network. It depends if it's a hospital, or a bank, but whatever's needed for that building to continue its business continuity. So if you remove an asset, you remove a functionality. Traditionally, as structural engineers, we would do blast assessment modelling. And this would be, you know, what happens to the facade and the structure of a building when a car bomb goes off. We would do 3-D modelling. But the threat profile has changed, and we're now talking Smart. And a Smart threat can, again, remove complete functionality of a building, which would impact our clients significantly,

Matthew: And what about the human side? Are you looking at anything to do with social engineering?

Peter: Yeah, we look at social engineering. Really the human side is the only side we look at. The number one asset to protect is human life and wellbeing. But, you know, we don't have to talk about hackers. You know we're not talking about people who try and attack your network. You can attack the human side. It's actually the easiest way in. You try and manipulate somebody through their naivety. And that's the easiest way to hack a building, actually.

Matthew: And do you find that's quite common?

Peter: Very common, yeah, very common.

Matthew: Have you got any examples of some of the sorts of projects that you've worked on with this type of specialism?

Peter: Well we have, as WSP, we have a security risk department, of course. And we look at it, again, the holistic threat, so we've done everything from walking into a bank holding a phone and a briefcase and just seeing how far into that bank we can walk. Walk with purpose. People don't like to stop you. Basically low-paid junior employees don't like to challenge somebody who looks like they belong. But we've also done, you know, network hacks, as the cybersecurity team. So we would do it physically, logically, Smartly.

Matthew: Awesome. It sounds like an interesting range of services. A big thank you to Peter Richards for joining me in the studio in London today.

In our next episode, we will be tackling how today our Access Passes basically mean that we carry around a picture of our face. But what if in the future, we could just simply use our face? We'll be joined by WSP security lead, Matthew Brittle.

If something in this episode has piqued your interest, then have a chat with us. Email Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

19 – Access Control

Broadcast: 18/07/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Matthew Brittle – Director, WSP UK

Matthew Brittle: We generally see security as being a disabler of anything that we want to do in a building, or anything else. And we have to turn that on its head. And with Smart technology and the way it's coming in, security has to be an enabler to a sort of better way to use a building.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into Smart buildings. In this podcast, we're talking about security. And joining me today is Matt Brittle, the head of security consulting for WSP in the UK. He's worked in the security arena for over 25 years, and is a chartered security professional, and principal of the Register of Security Engineers and Specialists. Welcome, Matt. And the first question for you is: What is a Smart Building, and why should we care?

Matthew Brittle: For me a Smart Building, from a security perspective, is something that's actually sort of, I suppose, been engineered and thought about in a way to begin with that reduces the vulnerability of security incidents, or potential security incidences occurring. And that's probably the greatest part of that is a Smart Building.

Then we add, what you would probably refer to, Matthew, as the Smart part of it, which is the technology over the top. If we link that with the design, then that technology overlay over the top is a lot more enduring, and a lot more efficient and effective and gives us what we want.

And one of the things that we always get pushed back onto is, in terms of security, is around how easy a building is actually to use for the people who are actually going to use it. And that for me is one of the sort of critical success factors around what is a Smart Building from a security perspective, i.e. is security seamless? Is it there, but actually does it actually enable people doing their jobs rather than disable them doing their jobs?

Matthew: So how do you see digital disrupting security systems?

Matthew Brittle: Well the biggest problem with digital, and as we get smarter, and we get more dependant on technology, and more dependant on systems, is the sort of human interface. And that's the biggest problem in anything that we deal with in terms of security. We can put all the technology in there that we want to but the...at the end of the day, there is a human user in that. Digital disrupts that in a way because it gives them the ability to interact with various elements within the building. It gives them access to an awful lot more data. So what we have to do is we have to be very, very smart about the technology we're using, how that information is used, and who has access to that information.

Matthew: In terms of technology, how much do you think it is shifting the landscape?

Matthew Brittle: I think it is shifting it massively, but we see that security is also embracing the sort of Smartness, I suppose, of technology in things that we sort of see going forward. So, as everything grows, security is growing alongside it as well from a technology and Smart basis anyway. So, yes, it disrupts things because it gives us other sort of threat factors where people can attack people, buildings, whatever else. But actually we're...that's the same as anything. We just, we're just creating the mitigations and the management sequences that go with that to go alongside the technology.

Matthew: What's your view on using mobile apps, or even your phone to gain access to a building, or a place within a building?

Matthew Brittle: So there's a couple of aspects here really with it. One is the fact that actually nowadays nobody really leaves home without their mobile phone. It is generally stuck to people, and it's one of those things that they notice if they've lost it very, very quickly. So from a security perspective that's great, because they always have it with them. And secondly, if they lose it, they're going to report that really, really quickly. Whereas, if we take an access card, or something, and we get to the weekend and somebody can't find it on a Friday night, they'll look for it Monday morning. If that was their phone they wouldn't. So there's some sort of hidden bits around applications on phones and things which are great.

There are some limitations at the moment with sort of phone applications and things, as well. And part of that is that everybody wants everything to happen seamlessly and quickly. Most of the phone apps at the moment for access control, you actually have to open the app on the phone to do it, which then starts to slow things down, and it becomes a balance of that. So I think we still got a little bit of a way to go before apps become Smart enough that actually it is seamless, and the user basically just walks past whatever they're doing and gains access.

Matthew: Yeah, I think some vendors actually quite like you having to go through the act of opening the app, because it adds another layer of authentication, because in order to get into your phone in the first place you need, you know a thumb print, a PIN code, a face. Whereas, if it's just your badge that you've dropped, you'd pick it up and kind of walk in.

Matthew Brittle: Yeah, I suppose that is, that's exactly the same problem as we have now, sort of cardless payments as such. You know, it's the same thing. It's a proximity issue. But you have the same issue with proximity access control cards as well. It just means that people would have to understand, if they have a sort of token or an access token of some description on their phone, what that actually is, and what that actually means, and the importance of that actual item.

Matthew: Maybe for access we shouldn't have anything physical, or the idea of me carrying around a picture of my face, when I could just use use my face seems a bit unusual. So with that in mind, do you think that facial recognition might be the natural way forward for security?

Matthew Brittle: So I really like biometrics as a way of controlling things because it's very hard to lose a biometric, you know? And you always have it with you. And generally we're all unique, so you're always getting a unique sort of token that's used every time in terms of what's there. Biometrics has had a bit of a bad press, I think, over the years, and rightly so. Things such as fingerprint readers, and stuff, and everything else, palm readers and everything else, they've all got problems with them. I mean and one of the biggest problems, I suppose, for a Smart Building is the fact that actually you've got to touch something. And that obviously has, you know, implications in terms of what's there.

Facial recognition, I think, as you brought up, is fantastic. Facial recognition works really, really well where you have a compliant subject. So if somebody who wants to get into the building, who will look at the camera, it works fantastically. And I would pretty much say that you're going to get a 99.999 onwards sort of result on positive sort of experiences with that.

And there are some great little tweaks in the sort of facial recognition sort of world. You know, and we always have this thing about lighting in architecture and stuff, and mute lighting. Well, you know there are some fantastic leaps forward with things like IR facial recognition. So the infrared part of it doesn't really care what the background lighting is. So you build in an infrared picture of the person, tokenize that and it's that token that gets compared each time. It doesn't matter whether there's bright sunlight outside, whether it's a different time of year, or anything else. And I think that's an absolutely fantastic thing to do.

Matthew: Does that work a little bit like how my iPhone recognises my face, where it puts that kind of matrix of dots on me?

Matthew Brittle: Yeah, it does. Most facial recognition systems take a number of points on the face, and compare those points, and the geometry between cheekbones, noses and stuff, and everything else is pretty much unique to the sort of individual in terms of what it does. And that's why I say with a compliant subject it works very well. When you have a non-compliant subject, when you have the face turned off say by an angle of 20 degrees or something, that's when you start to lose the ability to say, yeah, that definitely is the person, or that's definitely not the person, because as you say, it only picks up a number of the points. It can't pick up enough of them to say, 'Yeah, it's definitely them.' It sort of goes, 'Well, yeah, I think it's them.' And that's where the problem is.

But I think if, I mean if companies trialled 3-D facial recognition, I really do think they'd probably adopt it, because you haven't got to take anything out of your bag. You haven't got to hunt around for anything. You haven't got to remember anything. You've brought it with you. So, I think it's a fantastic technology. And I think going forward, I think it's something that hopefully will get adopted into Smart buildings.

Matthew: It seems that cameras are going to be really quite critical to security. Some of the things that I've seen on the market to do with Computer Vision, we now have analytic systems that are watching all of the CCTV inputs and basically being able to identify things such as somebody's fallen over, or a virtual trip line has been triggered, or perhaps even an unattended item. Do you see CCTV and Computer Vision being the future for kind of visual security?

Matthew Brittle: Well, I mean, visual surveillance systems, as we now move onto the IP systems, are going to be there. And they're gonna be there from a safety perspective. They're gonna be there from a security perspective, just for having that situational awareness inside a Smart Building. You know, it would be crazy to have a Smart Building where you didn't have situational awareness. So, yeah, I think they're going to be there.

Analytics now in camera systems is pretty common. Some of the artificial intelligence stuff that is now being weaved into video systems is amazing. You know it looks at gaits . It can recognise different sexes. They reckon sometimes they can recognise between different sort of countries of origin, and that sort of thing and whatever else. I think that bit is still emerging, but there is a fantastic amount of things that can be done in terms of different directional flows and stuff and everything else. Certainly stationary objects, loitering, things like that are all pretty commonplace technology now in terms of looking at the pixels on the screen and determining when they move and when they don't move. So there is a fantastic element there, which I think needs to be taken forward.

I think one of the biggest challenges for the security world, is that all of a sudden, we're getting an awful lot more sensors, and a Smart building gives us a fantastic amount of sensors that you can use. But you've got to be proactive in using those sensors because otherwise what do you use all this information for? So I think in the security world, security managers, security directors have got to start re-thinking as they get Smart buildings about how they can use the information that is available to them through Smart buildings to aid the security effort. You know, build up patterns of life. Not intrusive. I'm not saying, you know, individual patterns of life, but a pattern of life for the building, so you can understand when things are wrong. You know, you can understand when areas of the building that should be quiet and there should be nobody in them, suddenly have somebody in them, you know? And that might be a trigger to sort of say, 'Okay, is that someone breaking in', or it might actually be, as you said before, it might have been somebody fallen over and who is unconscious. So that first aid element becomes a lot quicker. So, I do think Smart buildings, the technology, the information available, is a fantastic leap forward for security. But security also have to embrace that and decide what they want to do with it.

Matthew: How do you help alleviate some of your clients' concerns around privacy?

Matthew Brittle: I think in general that the privacy issue tends to come from the fact that everybody assumes that when we're looking at something, or we're looking at details, or an access control door, that we're looking at an individual. And that generally is wrong. You know in the same way that the police won't look at an individual unless they have reason to look at an individual, and it's the same thing for security. What we're looking for is we're looking for trends. We're looking for things that are out of the ordinary. And it's not the person that we're really looking at. We're looking at the token that they use and everything else.

So, you know, for example, I suppose it's the age old thing that, you know, if you have somebody who uses a token in one part of the building, and a minute later that token gets used somewhere else in the building that you can't cover in a minute, then actually you know you've potentially got some sort of problem that's occurred. So I think that's one aspect in terms of what's there. And the other aspect I would say is that, you know, from a privacy perspective, and certainly in sort of workplace or anything else, I don't think it is invading your privacy. It's not like it's sat on your shoulder watching what you're doing. It's actually just tracking where you're going around the building, what you're up to and everything else. And I suppose in one way, if you've got nothing to hide, why is that a problem?

Matthew: It's about issues not individuals.

Matthew Brittle: Yeah. It's about issues. It's about keeping people safe. I think people always have a perception with security that actually security is looking at them to find something wrong. And it's not. It's looking at them to keep them safe. That's the sort of bottom line, I think, in terms of privacy. But, you know, organisations have probably got to turn that on its head a little bit and, you know, get away from probably what security has perpetrated itself, which is, you know, we're behind closed doors. We're a bit of black art. You know, we won't tell you what we're up to. And we need to become a little bit more customer facing and open, as well, to embrace what Smart buildings will bring for us, and you know the leap forward of acceptance from other users.

Matthew: If somebody was embarking on creating a security system within a Smart Building, what would your top tips be?

Matthew Brittle: Definitely first of all, and probably the biggest thing that they could do is forget about systems to begin with. Really what we're looking for are the outcomes. And it has to come back to that analysis at the front end that says: What do you actually want from security? And therefore, it's around, okay, so if you want surveillance of a building so you can look in areas, if you want secure areas that you can lock down, and things like that, then they're starting to drive you towards the outcomes of what you want, you know? It might be a lower cost in terms of operational security. It might be your corporate social responsibility. It might be the fact of lone workers. It might be the fact that you have shift change overs at sort of 11 o'clock in the evening and a group of people walking out to a carpark. You know, so the outcome might be that you want those individuals to be safe. If you start from the system end, you don't get that. It's getting the outcomes and then saying, 'Okay, fine. We've got those outcomes. Now, how can technology actually help us achieve what we want to achieve?'

Matthew: A big thank you to Matt Brittle, the head of security consulting for WSP in the UK. In our next episode, we'll be talking about platforms, the glue that brings a Smart Building together with thought leader from IBM's Watson IoT, Paul Russell.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

20 – Platforms

Broadcast: 18/08/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Paul Russell – Smart Buildings Leader, IBM

Paul: The people that's going to make Smart buildings successful, the ones that think about this, how you take physical, digital and human assets in infrastructure and combine them together to drive a predictive outcome.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into Smart buildings. In this podcast, we're talking about the digital glue that brings it all together: We're talking platforms. Joining me today is Paul Russell, a thought leader in the IBM Watson IoT business with a background in construction design and the electronic sector. Paul's passion around buildings, workplace and productivity is driving engagements with clients. First question for you, Paul, and welcome: In your opinion, what is a Smart Building, and why should we care?

Paul: Thanks, Matthew. Thanks for inviting me to your podcast. The way we talk about Smart buildings is really the shift from being a reactive asset to a predictive one. So how do we make all the things that go inside a building, which are really separate, work together? The human being, for example, all of the IoT sensors, all of the technology, and the environments as well, how do we actually bring that together in a way that it works together? Because at the moment, most buildings don't work that way. And so the goal for all of us in this industry is to achieve this outcome-based result for a building. And the most interesting thing that we find, it's not always the nice shiny buildings you see, it's all of those buildings that have been around for decades and will remain so, how do we make them Smart is the real exciting piece that we find.

Matthew: Have you got an example of some of those outcomes that your clients have been able to achieve?

Paul: Yeah, so, I mean, you know, we work with facility management companies a lot. They use our software, and they do some great jobs. Their industry are moving from an input workload to output because they've been driven by comfort, wellbeing, productivity, whether it's an airport, a hospital, or an office block. So really the FM industry are really challenging themselves now to actually get better outcome from the data that's collected, and how they can move to a predictable way of monitoring what the building is going to do, whether that's an impact to the weather, or cues, temperature, all the aspects that affect whether you feel comfortable are really in the FM industry's world. And they're a great example, but they're not the only ones -- real estate and others are all beginning to come together to try and solve the Smart Building challenge.

Matthew: I saw in the press actually that IBM were working with the facility manager ISS as to how they could use IoT technologies to, I suppose, find a lot of efficiencies in the buildings that they work in, and provide a better level of experience. So it's pretty exciting.

Paul: Yeah, absolutely.

Matthew: One of the things that I'm often asked when we're talking about how you make a Smart Building work and you pull those things together is: What is a platform, and why does a Smart Building even need one?

Paul: Okay, that's a great question, one I'm asked all the time. So if I can just change it slightly and talk about an example, in the City of London. Someone we're working with, who's actually acquiring a new build, and he's very much really a property developer. You know his world is quite simple in that respect. You know, he builds it, sells it, and actually wants to make it as most efficient as possible. But he used the words, which I think resonate here, 'digital backbone' for the building. Now we all know what buildings have in terms of IT equipment, and IT network, but he was talking about digital backbone that collects information about the building, whether it's energy, or occupancy, or wellbeing. So he was the first example of someone who probably wouldn't be thinking this way. We're using this language to say, 'Look I have all these suppliers in my buildings providing heating and ventilation, BMS systems, lifts, all the things that we need. I want to connect them to a digital backbone.' And I take that to mean a platform, and a platform that's secure, scalable, you know, allows me to actually maximise my costs and drive some value. And it's a new audience, certainly for IBM. It's a new set of people that we need to work with. And it's a new set of partners that I think are out there that need to come into this platform discussion.

Matthew: How is a platform different to a building management system?

Paul: They're probably not going to be much different if you break it down. So a building management system is effectively an architecture, and architecture is a platform. So they are very similar. I think the difference, I think, I would use is that we need to connect these different systems, like a BMS system, like an energy management system, environmental system, security systems, CCT, all the things that happen, into a way that I can extract knowledge from the data, because all these systems collect their data in silos. They are deployed by different people. They use different protocols, have different standards around taxonomies. So how do we actually get the data in a way that I can have a meaningful outcome? Too often, the data is too late. It's been collected, there's lots of it, but it is too late. People are complaining about the temperature, they've walked out of the room. It's too late. How do we get the data in place that we actually can have a predictable outcome? And that's really the platform discussion.

Matthew: What excites me about a platform, and why I think it's different to a building management system, is the ability to take data from business systems. So for instance, if you're an organisation that collects timesheets, for instance, I can compare what the building's doing, let's say its carbon dioxide levels on the open floor plan, and compare that over the year versus sick days. That might tell me whether or not I've got something wrong with my ventilation systems, or if actually I need to make a change to how the building is working, because I've actually been able to see the outcome in one of our business systems. And it's that interaction between the two that I think will start to prove business cases that in the past we probably would have considered quite fluffy.

Paul: No, I tell you, that's a great point. And what's really exciting, and you know from my background, is something called 'Knowledge Graph'. So Knowledge Graph, you know, the ability to take information from different entities that exist in different places and actually start to look at relationships and dependencies.

So, for example, you know the example of a lift, and the temperature, and a human being -- all are very different pieces of entities, all collecting different pieces of data in different systems. How do I take that data and start to look at what that data is telling me in a predictable way, and using a Knowledge Graph? Something that Google started many, many years ago. It's very common now in most large organisations, especially in finance, and elsewhere, around fraud detection. How can we take Knowledge Graph and apply that to a Smart Building context, taking all of this data and applying it in a way that you start to see anomalies? Which building is my problem this week? Today? Last week? What happened last year compared to the next 48 hours? What is the impact of the weather? What is the impact of the traffic? You know, the traditional BMS systems can't cope. The architecture underneath is not right. Knowledge Graph changes that, and that's something that, you know, IBM and others are really excited about, because I think that's probably going to be something we'll see much more of in the future.

Matthew: And it just kind of makes sense. If you think we spend 90% of our time in buildings, why would we not try and make those better?

Paul: Absolutely.

Matthew: I want to hear a little bit more about the sorts of issues that your clients are facing, because it seems that with the technology that you've got, you're able to make a difference.

Paul: Yeah, there's so many issues. I'll try and keep it down to three. They're very different, but I'll go through them. The first one is skills. You know, so we're talking about a very digital discussion. Buildings are traditionally not a digital place. You and I are very digital in our bags and our technology on the desk here, but generally buildings are not really digital. Therefore, the skills of the people managing the buildings are more analogue, less digitised. So there's a skills issue across the industry wide, which is a great opportunity for IBM, yourselves to really exploit with your consultancy, because a lot of people say, 'I want the Smart Building, but I don't have the skills, and I can't afford the skills, so what what do I do?' And it's a bit of a caught in the headlights here, so we've got to fix the skills issue.

I think alongside that, there's some real issues in terms of data standards, and in terms of all of the different ways building systems can spurt out data. There's a whole industry now trying to resolve the standards in buildings to get to a point where that data is secure, where I can trust the data, and therefore I can have an outcome.

And I think the final thing is just really energy and environments. You know, we see now in the climate we're living in, you know the impact of energy on buildings, and in environments around a building, in the cities especially, is a huge challenge for buildings to be Smart. And everybody's now looking not just inside their own portfolio, but what is the impact to my people coming to work? It might be an airport, or a hospital. So looking wider. So you're starting to go back into the Smarter city areas. And I see lots of customers beginning to, wanting to try and pull in data. We talked about the weather data. You know, if I know that it's going to rain tomorrow, what can I do if I'm an FM provider? If I can predict the weather, which we can now, how can I use that to change what I do? And if I'm going to get paid on that as a service outcome, I need to be aware of it. So it's a real mix of different issues, but there's the top three.

Matthew: Okay, so skills, data, and imaging?

Paul: Yeah.

Matthew: If somebody wanted to set up a platform, so that they could make their own Smart Building, what would your top tips be?

Paul: Okay. I think job one would be get some exclusivity with the partners involved. I think, so real estate, FM, IT -- all of the people that are really part of what makes a building Smart, traditionally are very separate. So I think job one would be: What is the relationship like with those groups of people? Is there a way to bring them together? Is there most importantly a leader? I spend most of my time trying to find the leader -- someone who cares enough to actually make it Smart. Without that person, you tend to fall back into everyone's individual domains, and you end up getting a lot of confusion, and you just don't get very far. So that would be tip one, definitely. So that's your membership -- the human thing.

Top tip two, in terms of platform, is to look at, you know, what is the ultimate goal we're trying to get from a Smart Building? And if it's outcome for the individual using in the building, then how do we get that person, or that team, or whoever it might be, to the data that's needed? So we do this thing called 'Design Thinking.' You know, where we actually put ourselves in the shoes of the people: How do they think, feel, say and do when they use the building? And we work back the way, as opposed to 'I've got this great BMS system, and I've got this great cloud platform, and I've got these great sensors. You should buy it.' Which is traditionally what's happened, and that's left us in the problem we have. So definitely bringing together the design thinking side, and the platform side.

And I think finally, is to really look at what Knowledge Graph could do. The ability to take data and work with partners who've got those skills, to expose the data in such a way you can make some meaningful decisions from. And that's very much a machine learning, data scientist world. But I think an investment in that skill set, I think is you're going to reap benefits in the future.

Matthew: And they're all quite people-focused actually. So, get the sort of people to buy into it, be human in your design, and invest in the right skills.

Paul: Yeah, Smart buildings in many ways is about people.

Matthew: A big thank you to Paul Russell, thought leader in the IBM Watson IoT business. In our next episode, we're joined by Dr. Chlump Chatkupt, who talks to us more about Artificial Intelligence and its impact on the built environment.

If something in this episode has piqued your interest, then have a chat with us. Email Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

21 – APIs / AI

Broadcast: 01/08/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Dr Chlump Chatkupt – CEO, Placemake.io

Chlump: Essentially, our goal is to engineer the worlds that we want by discovering the fundamental structures and the underlying dynamics of our interactions in the world, and with places.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into Smart buildings. In this episode, we're being especially smart and discussing Artificial Intelligence. Joining me in the studio is Dr. Chlump Chatkupt, the founder and CEO of PlaceMake.io. He's a tech founder, mathematician, AI scientist, economist, engineer, writer, artist, musician, and swimmer, just to name a few. Whether as a researcher at LSE, or strategic advisor to Abbott Laboratories, or the mathematical mind behind a boutique consulting firm, Chlump has made a career of developing novel strategies, and building mathematical models, technologies, and algorithms. Welcome. And to jump in with our first question: In your opinion, what is a smart building, and why should we care?

Chlump: Thanks for having me. A Smart Building is any building that is designed to be fully integrated into a data or algorithmic pipeline. The result is a two-way binding. Any data or change that might be generated within, or by the building can feed into the greater system in which that building is embedded. And conversely, any data or change that might be generated within, or by the greater system that encompasses the building can feed into the building. In many ways a Smart Building is more akin to a computer than a building. We may in the future talk about a building being deployed, just as software gets deployed. Naturally, a Smart Building will have data and algorithms at its heart, and perhaps be designed to be AI first. But the deeper implication is that by leveraging data and algorithms, such an integration will allow us to serve in unprecedented ways the interests and values of people and yield a built environment that is designed to be people first.

Matthew: I really like that as a concept. Just to double click on that, what is Artificial Intelligence, just to make it really simple for us?

Chlump: The phrase Artificial Intelligence, generally refers to the science and engineering of intelligent machines, or computer systems. The intelligence that such machines, or computer systems exhibit, and the simulation of human intelligence by machine, or a computer system. Machine learning, you might have heard...

Matthew: Yeah, they often come in tandem, don't they when people talk about AI? It's always, ML follows pretty quickly afterwards. So is there a difference?

Chlump: Yes. Machine Learning is a subfield of Artificial Intelligence and embodies a set of approaches to the question of AI, and algorithms to solve specific tasks, such as classification. Machine Learning is often defined to be the science and engineering of setting a machine upon a task and teaching the machine to learn, that is to improve its performance with respect to the task, based on experience and data, to solve the task without needing to be explicitly programmed.

Matthew: So when we're talking about image classification, you mean a Machine learning could learn over time, for instance, the ability to recognise a face?

Chlump: It could be a face. It could be numbers. It could be symbols. It could be objects in pictures.

Matthew: So when I'm taking a selfie on Snapchat, and there's like a small box that comes around my face, is that Machine Learning?

Chlump: Yes.

Matthew: Okay. It makes sense. So, I want to hear a little bit more about your company. What is PlaceMake.io, and how can it help me?

Chlump: We are an AI company, and we develop AI technologies to solve location and mobility problems. In an abstract sense, location industries, as with others, are concerned essentially with signal detection. The better that one is at exploiting data to identify hidden patterns and signals, the greater is the payoff. Should I give some examples?

Matthew: Yes, please.

Chlump: So we have market measures that can track performance over time and can be used for assessment, investment management, portfolio benchmarking, and in the future, it can serve as the foundation for financial instruments. We have leading indicators that can offer a perspective on the market, and can help to determine, for example, when to buy, hold, and sell your assets. Certain algorithms of ours can identify comparable places automatically across multiple dimensions, and also the optimal location for a physical asset. Other algorithms analyze people -- how they move around the city, their check-ins, sentiments, and preferences, and so on. Essentially, our goal is to engineer the world that we want by discovering the fundamental structures and the underlying dynamics of our interactions in the world, and with places.

At the same time, we are generalising this platform and developing it into a complete location Mobility Stack in the manner of Google or Amazon Web Services, that will be able to serve as the underlying infrastructure for all location and mobility applications. And individuals and organisations will be able to deploy their operations, and services -- everything from entire real estate portfolios, and urban models, to location-based services-- to a development environment on top of our stack, without needing to maintain separate private infrastructure.

You can think of the stack as an operating system that can power any location and mobility application, from site selection and evaluation, to logistics, provision of public services, and even, say, epidemiological surveys. Ultimately our mission is to help location industries to learn from their data to build better, more efficient Smarter industries and cities, and to be the premier location Mobility Stack of the world.

Matthew: So, some, just some small goals.

Chlump: Yeah.

Matthew: Exactly. So would it be fair to say that you can kind of tell me where the next up-and-coming place is going to be in a city?

Chlump: Yeah, we would basically look for different types of signals that can point you in that direction.

Matthew: Let's say I'm a famous fast food chain. Could I use your tool to tell me where to put my new stores?

Chlump: Yes, you could.

Matthew: And what kind of output would I get from that? So would it kind of analyse the city and tell me where I'll get kind of the most footfall, or where I will get the greatest profit per square foot, for instance?

Chlump: You can go further than that. I mean, you can understand how...you can understand, for example, transition probabilities: The probability that someone would go from one type of establishment to another one. You look at some of these other signals, so social media interests. You can look at sentiment. You can look at some of the more traditional indicators, so price per square metre. You can look at rent and so on. You can also look at the distribution of neighbours.

Matthew: Wow. So bringing all this together actually reveals so much more than a traditional kind of piece of real estate work would.

Chlump: Right.

Matthew: Let's think a little bit more broadly now about Artificial Intelligence and the built environment. How do you kind of see the future of those two things working together?

Chlump: Well, as celebrated AI scientist Andrew Ng observed, AI is the new electricity. AI will become increasingly foundational, transformative, and pervasive. AI, robotics, autonomous vehicles, and other technologies can be expected to enable continuous real time data generation, collection, aggregation, management, and analysis. Enable dynamic operation, intelligent monitoring, management, and optimization of the built environment. Transform transportation, logistics, and retail. Enable predictive maintenance, hence, manufacturing yields. Optimise and streamline design, and construction processes. Facilitate risk mitigation, automate facilities management, automate quality testing, improve supply chain management, optimise R&D operations, and automate support functions. So essentially, the built environment would become a dynamic, interactive, human-centric element that can respond to, and influence behaviour, and be more sustainable, resilient, and accommodating.

Matthew: So it's going to touch all parts of the built environment?

Chlump: Yeah, pretty much.

Matthew: Wow. If you had to give one kind of prediction, what would it be?

Chlump: I don't like to predict.

Matthew: You need the data. Let's think about some practical applications, then. If you were somebody that was considering using AI in your building, or your city, what would your top tips be to them?

Chlump: Adopt an AI first attitude. By that I mean think of AI as fundamental and not supplemental. Adopt AI early. People drastically underestimate the rate of change, and the changes will arrive sooner than people realise. And, furthermore, acceleration means that change will come increasingly quickly. Accelerating returns will accrue to those who effectively leverage AI, and conversely, those who fail to take advantage, will face an ever-widening gap. Promote AI and data sharing, and actively forge strategic partnerships. The two principal problems right now are opaqueness and lack of standardisation, and progress in this space will be defined more by cooperation and collaboration than competition.

Matthew: Great words of wisdom there. If we want to find out more about PlaceMake, where should be go?

Chlump: You can get in touch with me.

Matthew: So we'll head to the website at PlaceMake.io. A big thank you to Dr. Chlump Chatkupt, the founder and CEO of PlaceMake. In our next episode, we'll be talking about the Appification of everything with Henry Okraglik.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

22 – Appification

Broadcast: 08/08/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Henry Okraglik – CEO, WSP Digital

Henry: Focus on why you're doing things, not the technology.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into Smart buildings. In this podcast, we're talking about the Appification of everything. Joining me on Live Link from Melbourne is Henry Okraglik, who's WSP's Global Director of Digital Services. He manages a global team of around 70 software engineers and analysts from all areas of software development, including mechatronics, mobile device software development, web development, systems integration, and Internet of Things design and implementations. Henry has founded several software development companies in the USA and Australia, and is well regarded as a software commercialization expert, and has worked in an advisory capacity with capital venture firms in Australia. Welcome, Henry, and the first question for you: What is a Smart Building, and why should we care?

Henry: Okay. So, if you look at the way we've traditionally dealt with buildings, we've tended to separate out the different disciplines and technologies within the buildings. The thing that's really changed things is the availability of low cost sensors that are becoming very, very powerful, and therefore it now is possible to make a building much, much Smarter by enabling us to interrogate all aspects of that building to improve the human interaction and experience and productivity within that building.

Matthew: Got you. So when we're talking about mobile apps, how do they differ from normal applications?

Henry: Okay, so most of us will be familiar with using our smartphones for using social media, or for looking up train timetables, or whatever it might be. And I think what we're able to do now is use our smartphones and applications on our smartphones to interact with buildings. So for instance, finding your way to someone's office or, in the days now where with flexible working, finding out where someone is sitting can all be facilitated through Wayfinding on your mobile phone. And we can take it a little bit further and even have it so that your personal preferences for lighting, heating, and cooling can actually be controlled off your mobile phone through an application. So we're really making buildings more personalised to the desires and experiences that people have when they're occupying those buildings.

Matthew: And do you think that it's mobility that's really adding the convenience?

Henry: I think it's a combination of the mobility and the underlying technology that makes buildings Smart. And it's that interaction between those two different technologies, the one you carry in your pocket in your smartphone, and the technology that underpins the infrastructure in the building and our ability to have those interactions.

Matthew: When I'm out and about, I'm seeing increasingly that more places have workplace apps. Why do you think they're becoming so popular?

Henry: I think it's just an extension of a trend we're seeing with mobile applications in every other walk of life. I think, you know, if you think back, you know we used to use mobile applications when the first smartphones came out to play games. We then used them for more utility functions like finding out what time our bus or train is arriving. And now we're extending that into interacting with buildings. I think this is just a natural extension along the continuum of developing smartphone applications.

Matthew: Some people think that the use of mobile applications and buildings is the wrong thing to do because it gives the kind of expectation that, for the first time ever, that to use a building you need to bring your own hardware, and if you're looking down at your phone, you're not looking up and enjoying the building. So my question to you is: How true do you think that point of view is?

Henry: I don't think that those views are mutually exclusive. I think that you can experience a building as well as interact with it. I mean we do this all the time in every other walk of life I don't see that buildings are necessarily any different. I think maybe for some people, the experience of using your mobile phone to interact with the building is new, but that was true of every mobile application that existed before it as well.

Matthew: Fair. When you're helping a client to design a mobile app what kind of a process are you taking them through?

Henry: Usually it's a question of: What are you trying to achieve as an outcome? And that will vary from client to client, but the typical things we see are things like Wayfinding: How does a person coming into a building find quickly and easily where they want to go? And an application is a very convenient way of doing that. If you're looking at things like improving the productivity of your employees, and looking at wellness, and the health of your employees, then it might be more about personal comfort to do with climate and lighting, or even finding out when the next yoga class is that the company is running -- all those sort of things. So I think you've really got to start, as we always do in software, is finding out what are the requirements. And that will vary. I mean, sometimes if you're dealing with a building owner and manager, it might be about reducing the operating costs by getting a better handle on the heating, cooling, ventilation and air conditioning system. If you're an employer, it may be about employee wellness.

Matthew: Understood. And what kind of issues, are you seeing with your clients, if you had to name a few?

Henry: I think the couple that I was just referring to come up again and again. So, building operators and managers are typically focused on the cost. And so often, they want to look at things like: How do I get a better handle on how my building is performing? And they might own a portfolio of buildings and they might be interested in how the gas, electricity and water is being used in comparison to other buildings, and how they can optimise that. Often we now see building tenants wanting to make their place desirable for employees to work in, and therefore it might be more about personal comfort, and being able to locate where you're working, or different spaces that are available for say reflective thinking, or for group work, or somewhere private for more private type work.

Matthew: Would it be fair to say that an app is the key to success on some of those use cases?

Henry: I think it is because everybody's got a smartphone and so it's quite convenient. And I think most people are used to referring to their smartphones whenever they need to know something. So I think the only thing new here is really not the use of the mobile phone and the application, but the interaction with the built environment and the building that you occupy.

Matthew: What would your top tips be for those embarking on some kind of digital integration in the built environment?

Henry: The first and most important thing is being very clear on what outcomes you're looking for and what your objectives are. Because unless you've got those clear, it becomes like a laundry list of possibilities, and that's not really very helpful. It's also very expensive kitting out a building to be Smart so that you can interact with it, so you wanna be very sure about why you're doing this, and what you're trying to achieve, and not getting too caught up in the hype and the possibilities of what can be achieved. And so, you know I always encourage our clients to think very hard about: Why are you doing this? And often that's a very difficult conversation because it's much easier to say, 'We want to make the building Smart.' And that's not really very helpful if you're trying to design an application. Far better to focus on the occupants, or whether you're managing the building and trying to achieve cost savings, or you're trying to make the workplace more productive, whatever it might be. That seems to me to be the number one thing we should focus on. Everything else from there becomes much more straightforward.

Matthew: A big thank you to Henry Okraglik joining us from Melbourne.

Henry: There was some challenging questions there, thank you very much, Matt.

Matthew: In our next podcast, we'll be talking about why the Blockchain will be so important for the built environment, with two guests. Firstly, Jonathan Jones from Blockchain Technologies Limited, and John McDermott from WSP building services.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP.

Smart Thinking Podcast

23 –Blockchain

Broadcast: 15/08/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewees: Jonathan Jones – Director, BTC. John McDermott – Associate, WSP UK.

Jonathan: Databases are dead. Enter the Blockchain.

Matthew: You're listening to Smart Thinking, a podcast by WSP. I'm Matthew Marson taking you on a journey through Smart buildings. In this episode, we're talking Blockchain. Today I'm joined by Jonathan Jones and John McDermott. John is an integrated design specialist, who's written a paper about Blockchain and its implementation in the construction industry. Welcome, John.

Jonathan Jones is the business development manager at BTL Group, who are a blockchain company that have created a private blockchain platform. Before working at BTL Group, Jonathan had helped to develop the subsystems for the European Space Agency's ExoMars Rover and NASA's THOR TEA project. Proving that the sky isn't the limit, we're going to talk about how the blockchain may run our buildings and cities in the future. Jonathan, could you help make this simple for me? What is a blockchain?

Jonathan: So for me, a blockchain, at its sort of most abstract level I guess, it's a distributed, append only database.

Matthew: Okay.

Jonathan: And it's, yeah, that's, in its simplest form that's what it is.

Matthew: So it can never take something off it.

Jonathan: You can't take things off it, so it's append only, and it's distributed, and those are the two of the core principles. And I think the other two, that sort of preserve the integrity of the data in that database, they are cryptography, and consensus. And you'll hear, pretty much all of those terms thrown around at different times, and they're all very old concepts, actually. They're all sort of 40 years old, 50 years old in some cases, but you bring them together...

Matthew: And that's what makes it new.

Jonathan: ...And that's what makes it new. It's that new combination. It's a new recipe that brings about these new benefits and new characteristics that we can use in certain situations to improve the way that we interact.

Matthew: And why would I use one?

Jonathan: You would use one in any situation where you have a trust barrier.

Matthew: Okay.

Jonathan: That's really what it is at its foundation. It allows two or more parties, or any number of stakeholders, to interact on the same common platform, and trust the data that they are swapping, or engaging on.

Matthew: Okay, being cynical here, I think to a lot of people blockchain is still looking for a use case. Would you agree with that?

Jonathan: Yes and no.

Matthew: Okay.

Jonathan: Yes and no. I'll be a politician on that one, because on one hand, no, I think that there have been some really positive use cases come out of blockchain so far. I mean as, for all the sort of stick that it gets, Bitcoin is actually a pretty good example of a blockchain. There's lots of stories about it being hacked and so on, which aren't necessarily true. You know, in the public domain, so sort of Bitcoin, Ethereum, but also in the private domain, you may have heard of Hyperledger, or Interbit, for example. there have been some really interesting use cases as well. One really interesting one I've seen recently is Northern Trust developed a platform for private equity, and that's actually live and has been in production since 2017.

Matthew: What does it do?

Jonathan: It basically manages the administration and management of private equity transactions basically. And that's really the first step in blockchain development. So, getting that shared platform, that mutual environment for parties to come and basically generate a new data stream, but it's a new type of data stream where two people are sharing that information.

Matthew: Most of our audience will be more familiar with the construction industry. How do you see a application of blockchain, or distributed ledger technology in this industry?

Jonathan: So I think that the first thing for me to do is caveat this with a I'm a big proponent for blockchain, so prepare yourselves for a very optimistic outlook. But I believe that blockchain technology within the construction sector, in the Smart building sector, if you consider the number of stakeholders, the vast number of stakeholders that may be involved in any given sort of construction project, the processes and procedures that people are going through, so the number of materials, the number of components that are coming together, that all have to happen, you know, sequentially at the right time, and the right budget, and so on. There are so many different moving parts there, and so many different instances of people working together, or collaborating. And we said earlier that what blockchain does is it gives you that mutual environment, or that platform to come together across a trust boundary and agree on the status and data.

Now if you just imagine any construction project, all it is is a scaled-up version of that. So, if we had, for example, supply of some concrete, or some element going into a big construction project, or infrastructure project, we could trace that from its initial sort of production, all the way through its delivery to, I mean its storage, its delivery to the site, its sort of use in whatever it was supplied for. And then we can kind of build up this very trustworthy, immutable identity of the building right down to the last sort of molecule of gas in one of the pipes that's running through it. You know, it really does, the possibilities are only limited by, I think, maybe governance and how we actually want to implement things rather than the technology itself.

Matthew: John, if I could ask you for one of the use cases that I was thinking of is where your materials have come from. For things like the WELL standard, or BREAM, one of the requirements is that you can prove where your materials have come from, and the kind of sustainability of them. So I was thinking that you might be able to use some kind of distributed ledger technology to help prove some of that, or even perhaps what the material emits in terms of off gassing, which might be included in your furniture, for instance. I think that it's a really simple use case that we can apply quite easily. I mean that's just my opinion. What is your opinion on how far away you think we are from a specific application of things like that? And I'd love to hear a little bit more about that application and how you see it working.

John: I totally agree, Matt. I think that's a really good one. I think I'm right that companies like Amazon have started piloting test use cases of 'How do we track that from there to there,' and the trust that the blockchain brings in. One of the things that jumps into my head over time is, and one of the things for an engineer, is that at the moment, we base a lot of our design calculations at early concept stage on the documentation that's written by BSRIA, or CIBSE, and that's our benchmark for say electrical loading, or heat gains to room, etc. But where we might be going with blockchain, and we've been saying this for a while because we've been putting meters and these BMS systems in buildings for, you know, for some time now, but we've not really had the immutable data there we know is trustworthy. And that's where the blockchain might take us. So the interesting thing is then, for designers, and something I've been thinking about, a lot about, is how we get onto the front foot. How do we capture that information before the client turns around to us, or the person, the building owner, and says 'This building here that you've told me is X electrical load, actually, I've got 10 of these buildings and they're currently pulling this.'

So, it's watching that sway of where the data sits. So at the moment, the engineers have that knowledge because it's something that they do, and they base it on. So, within our organisation, we will do a lot of stadia projects. We will do a lot of healthcare projects. And we can look at those projects and we can come up with rates for what that would be based on experience. However, as you know, things are changing all the time -- efficiencies in equipment etc., so those things will vary. And it's how we get on the front foot. So there's the other thing is, take that onto a real-life situation within a building, and how a building is operated, maintained and managed. We do a lot of surveys on existing properties. If you were to go into that property and know that the information you get out of that O&M manual, or the information that you get out of that BMS system is 100% the truth then, you know, that's going to change so much.

Matthew: Understood. And I think the transparency that it's going to provide is actually going to be a challenge for design engineering consultants like ourselves, because it will make our clients so much more sophisticated. So with that in mind, and given the information that you've provided, if you had to pick a particular construction sector which might become an early adopter, who would they be and why?

John: You're obviously going to jump to the public sector. On the back of everything that's happened with building information modeling within the construction industry, and kind of the, you know the movement forward in that field has been driven really by the government and implemented in the public sector. I think, again, we might have discussed this in the past, but I think there's a BIM Level 3 document that sits out there somewhere in the world. And that was published way before people were really talking about the implementation of blockchain in the construction industry. But it looks at what the future might be. And very interestingly on one of the diagrams, documents, and I'll share this with you, but it kind of says that we're looking for a digital kind of infrastructure to sit this on to automate, and to carry data, and to run contracts on, etc. So, in a way, it was kind of hinting at what the blockchain, some of the things that we're saying the blockchain might do. So yeah, I really do think the public sector is the one that will be the early adopter if blockchain is implemented in the construction industry.

Matthew: It really excites me actually that blockchain could be the thing that plugs the gap between the design and the operational part of a Smart Building. I think there are quite a few people out there that could competently specify something to do with Smart, but there are very few skills that can take a construction and turn it into something that you can reasonably operate.

John: Yeah, no, I totally agree, and I think it's also the accountability side of it. So that the client becomes empowered will scare a lot of people. But that can only be a good thing in many ways. And as you were saying, Matt, how can we have Smart buildings, if we don't have accountability for design and installation? We can make a wonderful Smart Building design and have great ideas about how we're going to capture that data in the software, but fundamentally if the the wiring is not in right, you know. And how are we going to know that, because at the moment we don't have those processes in place, of how many buildings are handed over that, you know, just, they're inferior.

Matthew: Yeah. And with that in mind, who do you think contractor, client, or consultant -- who is going to gain the most from the application of blockchain?

John: I think at first the client, but in the long term surely everyone has a lot to gain from it, to be honest.

Matthew: Great. So if you had a kind of top tip to share with the audience about blockchain, what would it be?

John: Don't ignore it, for one. From a construction background, we don't all need to be cryptographers. We don't need to understand exactly how the blockchain works. But what I do you think we need to be thinking about is how it's going to be applied, and how it's going to change our profession.

Matthew: Jonathan, if somebody was looking to implement a blockchain for their construction project, what would your top tips be?

Johnathan: The first tip would be to, sort of, aim big. So, massive vision, as always, but start small. And this is what we've done in the energy space, as well. They've just run, as an example, you know there's a really impressive vision of how the whole landscape can be digitised. And similarly, you can do a very similar thing with the construction industry. And then also that could integrate with, you know, Smart buildings after they've been developed, and so on. So I think, you've got to have this impressive vision, but obviously you're going to need so many people involved to make that happen. Because everyone's incentives are slightly misaligned, and therefore you're going to need everyone around the table. So I think that's a really important discussion to be having. And that's how things are gonna change on a large scale. But at the same time, sort of in parallel I think, picking something small. So for example, you know that designer, the concept of having like a designer log, that you mentioned. You know there's nothing stopping people implementing things of that scale that have real benefit in the short term. Maybe not huge benefit, but you can still start to see how the sort of concept, or the architecture of a blockchain could help whilst having the bigger, sort of, visionary discussions.

Matthew: Okay, so think big, get everybody involved, and see what sticks.

John: Exactly.

Matthew: A big thank you to Jonathan Jones, the business development manager at BTL Group, for joining us in the studio. Some great advice there from BIM and integrated design specialist John McDermott from WSP.

In the next episode, we'll be talking about the scale of Smart when it comes to a city, with the global director of urban development and smart cities leader at Siemens, Julie Alexander.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

24 –Smart Cities

Broadcast: 28/08/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Julie Alexander – Head of Smart Cities, Siemens

Julie: A Smart City is not a place. It's about improving the lives of the people that live in cities.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into Smart buildings. In this podcast we're thinking big. It's all about Smart cities. Joining me in the studio is Global Director of Urban Development and Smart cities leader at Siemens, Julie Alexander. Julie works with cities around the world showcasing the role of infrastructure and integrated technological solutions in urban development. Her recent book "Smart Cities, Cities in the digital age" illustrates the importance of digitalization in the field of critical infrastructure. Julie is a member of the Smart London board, Institute for Future Cities board, and Urban Living Partnership Advisory board. Julie is also the chair of the managing board of UK Collaboratorium for Research in Infrastructure and Cities. And to jump straight in, Julie, in your opinion, what is a Smart building, and why should we care?

Julie: Well hi, Matt. So Smart buildings, I think, is an evolving topic. As technology moves forward, we're seeing more and more interesting solutions for buildings. So for me, Smart buildings is very much about connectivity, how we extract information from a building, how users can use the building more effectively. Everything from sensing occupancy, to sensing temperature, indoor air quality -- all of this data now can be extracted from buildings and used in ways that makes managing those buildings easier, more affordable, more convenient for the users. So it's very much about the integration now of digitalization into buildings.

Matthew: And with that kind of as your opinion on it, why would we care about it?

Julie: Well, I think there's so much potential. And I think that's yet to be fully discovered. So, depending on whether you're a private building owner, occupier, or it's a public building, I think there's different potential opportunities. So, as residents, or a homeowner, you might be more interested in about: How do I save money on energy? How can I manage my heating, lighting, when I'm not in the building, when I'm away from home? So digitalization in Smart buildings gives you that capability to have more control, more understanding of how you operate your building and its systems.

Similarly, for commercial buildings, or for public buildings, there's all kinds of opportunities to manage and optimise systems: Cooling, heating, lighting, but also understanding how people move in a building. I think this is a real opportunity for commercial offices. So, are building spaces occupied? There's so much demand for commercial space in buildings today, and yet there's a huge amount of space sitting empty. So by correlating that data and pooling those datasets together, we can begin to optimise building spaces more effectively.

So, it's all about understanding how buildings are being used, who's using them, what are the systems, how can you use buildings more efficiently and more flexibly? And I think Smart buildings really brings us those kinds of opportunities.

Matthew: So you think it's all about the potential?

Julie: I think it is, yeah. I don't think we've fulfilled that potential today. We've had building management systems for some time, which helps understand a building in real time, control that building. I think what we need to move to is more of a predictive, or prescriptive approach. So how do we know when a building will fail? When do we order that spare part that we're going to need? Ideally, not when that item has broken, but actually sometime in advance, so you're ready, you're making those changes before any failures occur. So I think the potential really is in that predictability, and also understanding how people use buildings differently.

There's a lot of work out there at the moment about the future of buildings, the future of the workplace, how people want to operate in spaces differently. And I think that can really be advanced through understanding data from people, from building users, and from the building itself.

Matthew: Let's up the scale now and talk about Smart cities. What are they, and how are they different to a Smart building?

Julie: Well, a Smart city for me is not a place, it's a concept. And it's very much about the integration of data systems, how we communicate more effectively as citizens. So many people will say, you know, 'What's the Smartest city in the world?' Well actually, every city has a different approach to their digital journey. And it's not about who's the Smartest, who's the most connected. It's really still about: How do you make things more efficient, more livable, more affordable? How do you attract investment into your city? And if you can do that more effectively through optimization of infrastructure, or of communication capability, then really this, for me, is what Smart cities is about.

And so what I talk about with cities, when we're speaking to mayors really is: What are your objectives? Are they environmental, are they economic, are they social? And how can you meet those objectives more efficiently through information capture, data correlation, data science, and really help them understand what's going on in the city so they can make better decisions. So it's really data driven decision making, optimization of systems, and more interaction between people and cities, and allowing the city to communicate more effectively with their citizens.

Matthew: Do you see a future where cities will use this type of technology to actually compete with each other for residents?

Julie: Absolutely. And I think we're seeing signs of that now. So you do see cities saying, 'We want to be the most digital, the most innovative, the Smartest city. And by that, I think they're sending a message to their communities, and that's not only residents but also companies. They're saying, 'Come and invest here. Come and set up your business, create jobs, create a new sector, a tech sector.' Every city now wants their tech cluster. And I think they're seeing this as a real USP. Even private developers are saying they want to do something with start-ups, and creative digital communities. So I think this is the latest thing.

And sustainability is still there as an underpinning message. But in so many cities that's implicit now, and that has to be delivered. There's still a lot of investigation going on around what is Smart, what is digital, and what does connected mean for us. And you see the first steps being made in broadband, using the 5G connectivity now, using different spectrum to connect different people, different devices. And so cities are beginning to test this out. Where do we start? How do we move forward? But absolutely, I think, as with any kind of messaging, or investment, cities really see this as an opportunity to up the ante in city investment, and quality of life, and creating good environments for people to live in.

Matthew: Have you got an example of some of the issues that you've helped a client tackle?

Julie: Well, I think London is a great example. So many good things going on, and some of which are really driven by the city, others which are happening more naturally because of the community that's built up here. A really good example that I like to talk about is, when we work with Transport for London, a world leading transport agency, where we worked with them to optimise the Victoria Line, the first of the metro lines we're working on in London. And what we did was install a digital signalling system that allows the trains to talk to the signalling systems. And this means that, without human intervention, the trains can move faster through the tunnels, more closely together through the tunnels. And so now we move 1,500 more people every hour. What that means for the citizen is that you don't have to wait for the second, or third train to come. As soon as you arrive on the platform the train is there. So it's a very much almost invisible or hidden intervention, but people are impacted by that day to day. And so, and I think this is the benefit of digital. It can happen in the background. Actually the users can really feel the benefit of it. So, for me, Transport for London really leading the way, and it's always a pleasure to work with them on some of these more advanced and forward-thinking technologies.

Matthew: Thinking technically, does the scale of a city add complexity?

Julie: Yes. I think you have to say that that is the case, because if you were to take a city like London, we're in London now, you've got one Greater London Authority, but actually 33 boroughs who have services they need to deliver, budgets within which they need to do that service delivery. And each are slightly on their own journey. And I know the GLA are working to bring them all together through the London office of data analytics, the London office of technology and innovation. But actually at that scale, it becomes very difficult because borough to borough there are different needs, and different requirements, different demographics.

But if you are working with smaller cities, one of the key advantages there is there's fewer city officers to have these conversations with. And you'll find some of the city officers having multiple functions. So they might head up IT and traffic management. And it begins to make those conversations easier. You can begin to understand some of the operational challenges more easily. So I think, simply on that management level, it's easier to work in smaller environments to get these things moving.

But also on a geographic scale, there are different needs from one end of a big city to another. So I think, yes, from an organisational point of view, the technology could be the same across the city but actually what they want to achieve with that technology could be very different.

Matthew: Yeah, it seems to me that digital actually provides a good way to get people to collaborate. And the example that I've got is doing some work for a regional government, and they had a real issue in predicting the amount of social housing that they needed to build because they were made up of seven different districts, all that had their own kind of different systems, or way of trying to forecast that. But the actual pot of money and the responsibility came at the regional level. And because they didn't have the right systems, and the right tools, they just found that a really onerous task. So, it just goes to show what can be done in a smart city.

Julie: Absolutely. Well we're seeing in the UK now mayors being appointed, so hopefully that will give some direction, some leadership around this topic.

Matthew: Yeah. So if you were a city looking to go Smart, what would be the top tips that you'd like to receive?

Julie: How to understand the operational challenges that we as the city are trying to tackle, so really getting down into the nitty gritty of the day to day problems that the frontline staff are tackling: Who's taking the calls of complaint? How are these being resolved? How could we better resolve them through the use of digital? Of course having that connectivity capability across the city is the number one check. If we install sensors, can we extract data from them? How do we bring that up into a capability, a tool, a platform, whatever you'd like to call that, that makes that data visible and understandable? You can collect data, but if you don't know how to read that data, it's still useless to you. So you have to have ways of bringing the data in, and understanding it, and getting the right people around you who can help you do that. And it's very much, in this day and age, about collaboration. No one agency, or organisation can do this on their own. So, understanding the ecosystem around the city I think, as well, would be one of the first priorities.

Matthew: Okay, so it's about understanding your processes. It's having data literacy, and it's being able to work together.

Julie: Absolutely.

Matthew: A big thank you to Julie Alexander, joining us from Siemens.

In our next episode, we'll be talking to the head of Building Technology Systems for Australia and New Zealand, Roneel Singh, about how he's using Converged Networks to make buildings Smart, Down Under.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

25 – Converged Networks

Broadcast: 29/08/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Roneel Singh – Head of Building Technology Systems, WSP Australia

Roneel: A high capacity Converged Network is the fundamental building block of a Smart ecosystem.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into Smart buildings. In this podcast, we're bringing it all together and talking about Converged Networks. Joining me live from Melbourne is Roneel Singh, a technical director at WSP, and regional head of the technology systems discipline. His team focuses on providing technology and integration consultancy services. He's a leader in the field and has had exposure to a range of local and international projects which use technology and innovation to focus on the holistic solution. Roneel is frequently involved in the development of integrated technology strategies and master plans in the planning stages of major precincts that ensure technology systems infrastructure is correctly planned, staged, budgeted, and designed. A big welcome and first question for you, Roneel is: What is a Smart Building, and why should we care?

Roneel: A Smart Building is a building that focuses on enhancing the experience of the user in the building, and providing a more functional benefit to the owner, the occupier, and the tenant. Why should we care? I guess it's quite important that we get the most of our assets, and we maximise the benefits, not only from a monetary standpoint, but also from a user experience standpoint in everything we do in the built world.

Matthew: What are Converged Networks, and why would they be preferred to the traditional way of designing one?

Roneel: Traditionally buildings had multiple networks that had different services running on them. Now these were proprietary networks. They were siloed and they were locked away. As the IoT revolution, or the Internet of Things revolution has happened, you traditionally end up in a building today with up to seven, eight, maybe more different networks. The danger there is that the networks are essentially unprotected. They're using systems that are not IT grade, or enterprise grade. Therefore, you have a myriad of different systems and technologies on the solution. A converged network takes all of that together and puts it into an enterprise network, or essentially an engineering network that would then have the Smart infrastructure running on it. It removes silos. It removes additional costs, and it makes a freeway, essentially, for all of the services, all the technology platforms to work on. I think the key term there would be that you're creating a Smart ecosystem to allow all of the communication to happen on an open standards based, and a clearly protected network.

Matthew: Now that sounds a little counterintuitive. I can understand the benefits of it being cheaper from not having so many networks being run in tandem. But if I bring everything together, does that not expose my business to being hacked through something like an IoT fish tank?

Roneel: No, it doesn't, because what it traditionally does is, if you look at the security, or the BMS, or other networks that have been put in place, very few networks are centralised the same grade as your IT enterprise network would be. So the idea of pulling everything together into one converged solution enables you to actually put in multiple levels of files. It allows you to put in multiple grades of security. You have your enterprise security control all the ins, all the outs. You actually can then set up your system so that you've got layers of protection, and then have essentially penetration testing on that whole solution, as opposed to separate silo-based solutions that generally, in a building, or a Smart Building provide the back door entry.

Matthew: How far do you think we are from this being a standard specification for a building?

Roneel: Depending on what part of the world you look at, if you're looking at the Middle East, the digital converged network is essentially mandatory. If you're looking at the US, Europe, and possibly Australia, there are different grades of converged networks. I think in Australia, at the moment, and in the Asia Pacific region, converged network is the norm. How it's deployed, and how it's set up to be a true open source ecosystem is still being debated. So I think we're probably a couple of years away from most specifications requesting a converged network just for the engineering services, if not converged with the enterprise services.

Matthew: Okay, but you're certainly seeing it becoming the norm?

Roneel: Very much so. We consider that as the norm in 2018 to ensure that there is a converged secure network for all your services platforms in a net based building product.

Matthew: Are there any client examples that you'd be able to share with me?

Roneel: Sure. So, there are multiple fine examples at the moment that we're working through from large precinct-style developments, to some very bespoke hospital developments, or healthcare developments. So the Cancer Centre in Sydney Adventist Hospital has enabled us to provide a fully converged network to allow all aspects of technology to be rolled out into a room that's quite a specialist room with quite specialist technology solutions that have been deployed to enhance multi disciplinary meetings, and treatment solutions.

Matthew: Have you got an example use case that you'd be able to share?

Roneel: Well the two use cases I can share with you, one being the Cancer Centre, the Sydney Adventist Cancer Centre, where what was enabled was that we ensure that there was a converged network from a hardware and a communications platform that allowed us to get onto the, allowed us to put any technology on top of it, as long as there was a set of rules that allowed that communication to occur. So we set a benchmark and rule, which is standard open protocol IP rules, and then we released that specification to any of the trades, or services, or technologies that need to sit over the top.

A similar thing happened in a precinct scenario with Yagan Square, which is a large, open space in WA, is their city, civic ... (??) port. We were able to create a converged network to allow every service on the site, including their IT, their Wi Fi, their signage, their performance systems, security and whatnot to sit on a single converged network to then be monitored and controlled in a unified manner so that the precinct was Smart. And in the future, as you add things to that precinct, it's in a very controlled and managed way.

Matthew: When clients ask me about creating a Smart Building, one of the first things that we always talk about is creating that base layer of infrastructure. I just wanted to get your opinion on how important you think that is.

Roneel: It is essential. It is the one element that won't be changed when the building, the tenants change, or you do a light refresh of the building. The core infrastructure is like a road system, I guess, because if you don't plan that properly, you will spend every year extending, duplicating, or multiplying that process to get your system, and your network right in infrastructure. It allows you to then add on what you want from an IoT point of view, whether it's wired, it's wireless, or whatnot, to be quite seamless and to be always integrated and not siloed.

Matthew: If you think about how quickly technology changes, how are you able to know what the right infrastructure is not knowing what the future holds?

Roneel: Infrastructure hasn't changed in terms of the cables, the cords. There's a very slow progression in change. It is the technology on the top that actually sees more change and more diversity. The core there should always be people, process then technology. So if you focus on the people and the process and what you're trying to achieve, the technology that you put over the top of it can change over time, or every year, if you need to. The base backbone of the infrastructure will be quite similar, as long as it's reliable, it's resilient and it's redundant.

Matthew: I suppose in the same example, the analogy of the road network, the roads haven't changed, but the cars that go on top of them are certainly a lot fancier.

Roneel: They are fancier. They are faster, and they're autonomous nowadays. And you need to take a very high level helicopter view to be able to see what you think the changes are and try to be slightly forward thinking. The infrastructure itself in a total cost of construction is very minute, so doubling even the cost of the infrastructure shouldn't really impact your total cost of construction significantly, but the benefits will be very significant if you do that.

Matthew: When someone's thinking about a Smart Building, and in particular their core infrastructure, what would your top tips be?

Roneel: Top tips would be to ensure that you're treating the infrastructure as a casino, or a bank would for their critical network. It is a critical piece of infrastructure. It needs to be thought and designed in that manner. And then, it needs to be there to have a real framework around it so any IoT platform, or any system can fall on top of it. So, it is a Smart ecosystem that you try to create where things are all literally plug and play.

Matthew: A big thanks there to Roneel Singh, the regional head of technology systems, joining us from Melbourne. In our next episode Jay Wratten joins us to talk about the experience of being in a Smart stadium.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast, from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

26 – Smart Stadia

Broadcast: 05/09/2019 (https://soundcloud.com/smart-thinking)

Editor: Matthew Marson

Guest Host: Nikki Hammer – Associate, WSP USA

Interviewee: Jay Wratten – Vice President, WSP USA

Matthew: This episode we've got a guest host, and it's Nikki Hammer. Nikki is an associate at the Boulder Innovation Center in Colorado. As a project manager with 15 years of experience, she helps coordinate multidisciplinary WSP project teams to implement Smart building solutions. Nikki is a professional engineer, and a LEED AP, and as part of her work at the Innovation Center, Nikki provides the opportunity for her clients to experiment with Smart buildings technology and evaluate real time data for their benefit.

Jay: Most stadiums get built once, yeah, but then they get renovated over, and over, and over again. And so the stronger that we can develop that relationship with the client, the end client, either the team, or the league, or the facility owner, I think it benefits us.

Nikki: You're listening to Smart Thinking, a podcast by WSP. I'm Nicole Hammer in Boulder, Colorado taking you on a journey into Smart buildings.

In this podcast we're talking about Smart sports venues. Joining me in the Boulder studio is WSP's sports sector lead for the US, Jay Wratten. Jay's recent sports experiences include two 70,000 seat NFL football stadiums, Major League Baseball spring training facilities, and he has conducted league-wide fan experience evaluations for Major League Soccer facilities. He has won numerous lighting design awards for his sports projects, and he specialises in adding value to sports projects in the context of fan experience by implementing Smart building solutions. Jay is reshaping the way WSP pursues sports projects by focusing on the business value that WSP's service provide. Welcome, Jay. First question for you: How do sports venues compete with television to attract people to the venue and create a better experience? Why actually attend a game in person, when a fan may be able to see and hear better at home?

Jay: Thanks, Nikki. And one of the biggest challenges we see in sports today is: Why go to the game, right? The TV coverage is great. And so as we're designing stadiums, what we're trying to find out is: How can we design them differently to make people go to games? One of the challenges that we see, and the opportunities for WSP, is in thinking through the way we enable a nicer fan experience, not just from when they get to the game but when they leave their house. So the fan doesn't see the game as starting once they come through security, but you know, how hard was it to get there in terms of traffic? Where can they park? How long should they plan to get through security? All the sort of little things that make it difficult to go to a game, what can we do in our sort of holistic WSP vision to make those go away? And then, how do we make it easier for the fans to then, once they're in the facility, either connect better to their team, maybe they would like to buy something and we want to help them find where the things are that they might be interested in. It might be as simple as helping them get throughout the facility. I think everybody can relate to coming into a gate and realising you're on the absolute wrong side from where your seat is, and how you get there, and how do you meet up with your friends? So we're seeing a real investment in facilities in presenting that kind of information to users, either through a mobile device, or through different technologies that would enable that.

Nikki: I see. It sounds like a true power of one solution offering for WSP. How is WSP using Smart to reframe our pitch around sports?

Jay: Well power one is a great segue. You know, traditionally, WSP may have come to a sports project with our, I'll call them siloed solutions. You know, maybe we were going to do traffic management outside, or parking management, or maybe we were going to do mechanical, or electrical and plumbing services design. Those are all great aspects of the expertise we can bring to a stadium. But, when we're going after them today, I think we think power of one. WSP's scope, our vision isn't within those silos. It's in that larger aspect of aligning. So we need to realign our pitch to align with their expectation. You know we've seen themes emerge. And we talked a little bit about fan experience, and that doesn't fall in technology specifically. It covers how we might design the mechanical system. It covers our security aspects. The same thing happens when you talk about sustainability. You know stadiums these days, and sports brands these days have to walk the walk. And so the role that a sports venue plays in the city, and its, let's call it its role modelship in setting the bar high for sustainability, means that we need to think about how all our systems combine together to lead up to that. You know, whether it's great water capture, you know from runoff on the roof, which you know covers a number of things that we might look at, and then, you know, how do we use that? And how does the team then evangelise that? You know, Mercedes Benz Stadium, which is one of the recent big projects in the US got LEED Platinum. First LEED Platinum Stadium in North America, and it was a big lift across the board, not just from WSP, but all the design team to achieve that.

Nikki: I see. And you and I were talking earlier about how the Denver Broncos stadium hosts over 300 events a year, six of which are NFL football games. So it seems to me that there's a huge opportunity for sports venues to act very differently in much different contexts than they traditionally would.

Jay: Yeah. I mean, you're absolutely right. Somebody told me the other day that the venues these days, we need to sweat them a lot more in order to get the money out of them as an asset. You know, so it's in the planning phase of most of the sports projects we've seen recently is the design that it will operate almost every day, and generally on a partial load. So instead of having 70,000 seats filled, you might only have, you know, a corporate event on the second concourse. And how do we anticipate that partial load operation from facility management perspective, and from a user perspective? If I walk into the stadium and all the concourse lights are off, and the air conditioning is off, and it's empty, it's a very different experience from me as a, you know maybe I'm just going to have a meeting in one of the suites, or something like that. How do we then enable that partial load to be just as impactful as the full sold out stadium experience might be?

Nikki: Interesting. It seems there's a great opportunity there. You were talking earlier about the fan experience. I'm wondering what WSP is doing to kind of differentiate theirself as a firm in terms of how we pursue and pitch that fan experience. Are there different sorts of players that we're engaging with in the marketplace?

Jay: Yeah, there is. I mean I think a couple things that I see us doing differently around Smart, one is the pitch. We're really refining how we go to talk to clients about Smart, if I can call it that, and figuring out we're not there selling a menu of services. We're selling that, we've talked about fan experience a bunch, but we come back to that. We're selling the holistic experience. The fans don't know or care how the air conditioning got there, they just care that it's the right temperature, right? And so when we talk about fan experience, we have all these enabling expertises, but we need to roll it up into this larger deliverable. And it means that generally we're pitching multiple services that aren't necessarily aligned around our traditional business lines but around the project itself. What does the project need? What does the client need? And how do we build a team around that?

And when we look at teams, our traditional go to the market was through architects. You know, so we would hope the architect would win the project. They'd send us a request for proposal. We might get on their team. A couple of themes I'm seeing now is that owners of sports venues are looking to other expertise. One of our big clients, HOK, did a big engagement with Visa, the credit card company, to look at how payment applications can affect the fan experience -- that journey. We're seeing a strong driver to bring in partners who understand, you know, digital differently. They understand brand differently. And how did the things that we do affect the way the brand of that team, or that stadium, looks? So we're partnering not necessarily with architects but with those kinds of players.

And then, lastly, I think the big pitch for WSP is in having a stronger relationship with our end client -- the facility owners. We definitely see a change in the way we talk to end users, knowing that, you know most stadiums get built once, yeah, but then they get renovated over, and over, and over again. And so the stronger that we can develop that relationship with the client, the end client, either the team or the league, or the facility owner, I think it benefits us.

Nikki: How do you think our sports clients see Smart?

Jay: That is a challenging question. I run into this when I go to pitch. A lot of our clients see Smart in two ways: They either see it as a way to save energy, or they see it as a series of tech gadgets. Partially that's because that's the way the market has presented it. They're used to people coming, you know, you talk about a Smart home or, you know, something of that nature, you're often thinking about energy efficiency, right? If I buy a Smart refrigerator it's somehow aligning its cooling with how much, you know, soda I have in the fridge that day.

And then our vendor competition, and they are competitors here in Smart, have been out there pitching widgets and gadgets that they can strap onto their stadiums to make them Smart. The way we need to realign ourselves when we talk about Smart stadiums is it's not a gadget. It's not about saving energy. It's a design philosophy. We're trying to get in early at the masterplan level and say, 'What do you want as an end user? How are you going to operate the facility? What best benefits your business and best benefits the fans?' And develop a design that supports those goals and executes those goals. And yeah, we're gonna have energy saving as part of that because it makes sense. And yeah, we're gonna have a couple of widgets, or applications that are that are applied that are fan-facing, but those aren't the drivers around Smart.

Nikki: Interesting. So, Smart truly improves the fan experience, enables better facility operation, and improves the overall quality of the venue?

Jay: Absolutely.

Nikki: A big thank you to Jay. We can really see a potential for Smart Services to change the stadium experience. Join us for our next episode with Garald Todd from the Middle East, where we discover how WSP Middle East is striving for Smart success.

Matthew: If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com.

Nikki: You've been listening to Smart Thinking, a podcast by WSP. I'm Nikki Hammer. Thank you for listening.

Smart Thinking Podcast

27 – Middle East Striving for Smart Success

Broadcast: 12/09/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Garald Todd – Director, WSP in the Middle East

Garald: Sometimes we find, in the Middle East region, that the ambition for innovation often overshadows the need to just get the basics right.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into Smart buildings. In this episode, we're talking about Smart in the Middle East. I'm joined today in the Dubai studio by Garald Todd, Client Director for Property and Buildings in the Middle East region, and Saudi Arabia country lead, with 13 years experience in the Middle East, starting his career working on some of the most iconic projects in the region as Fire and Life Safety specialist. Firstly welcome, Garald. And to jump into our first question: What is a Smart Building, and why should we care?

Garald: So everybody will have a different definition for that, but when I think of Smart, I think of a building that is reactive to how-tos. And the benefit of this needs to be in sustainability, energy consumption, efficiency, but not only efficiency in power and the cooling and other things, efficiency in how the building is actually used itself -- the optimization of the space, the use of space, the organisation of the building itself. All of that, not only saves the bottom line, or it should, but also should improve the wellbeing of the people using the building. So really, something that generates active useful data that then can be used by either your automated machine learning systems within the building, or operators of the building to improve the building's performance.

Matthew: With that in mind, how are you seeing Smart unfold here in the Middle East?

Garald: Right now it's a bit like Buzzword Bingo. Everybody wants to talk about it, but it ends up being expressed as gadgets. You know, robots taking people to meeting rooms, and other cool things like that. Well while that is cool, I don't know that it really hits at the heart of what Smart really should be and where it should be transforming our lives in how we use and operate buildings.

Matthew: Do you think that the expectations of some of the clients here might be different for those in more mature markets?

Garald: I think they're more open to pushing the boundaries. Everything about the Middle East is transformative. You know they're trying to transform a desert. They're trying to transform, I think, some of the stigma that surrounds the Middle East. They're looking to make statements. They're looking to gain global relevance. You know, you look at Dubai 10 years ago, you know, Dubai wasn't on everybody's mind. Now Dubai is internationally recognised. You know, so they're going a long way to that. And part of that is just pushing the boundaries, looking for innovation, looking for future tech, looking for how do we do something slightly different? So I think they're a bit more forward thinking, but I also think that there is so much going on that they haven't really dug into the meat of it yet.

Matthew: From some of the client conversations that we've been having, it almost seems that some of the basics need to be covered before we can move up into the more human experience parts. I think you were talking about the speed of construction means that some issues exist in commissioning.

Garald: The speed of construction, the availability of talented resource, the sheer scale and size of everything that's going on and all at the same time, means that we can't really have an intelligent discussion around something like HVAC analytics because the BMS isn't properly commissioned in the first place. So none of your systems are working as they were intended or as designed, by and large. So, you know, it's great to have a conversation about how do we make that more efficient, but let's get it working at least to spec first. And so that's one of the big challenges, I think, that we're going to see if we move into some of the sustainability and some of the energy efficiency world of Smart, let alone the customer experience.

Matthew: So which do you think will probably happen first if there were to be a big bang Smart project? Do you think it would be more on the operation side, or more on the experience?

Garald: I think the big splashy big bang Smart project is probably going to come out from a communities, district, or cities wide point of view from some of the new developments coming up out of Saudi. I think that's where the first real stab at it is going to happen in any real meaningful way. And then I think the second is, as the Dubai or UAE market matures, I think they're going to start looking at efficiency and sustainability in a real way to where actually we need to start decreasing our operational costs. We need to start making things really efficient. And I think we'll see a lot more traction on that. So I think it's a mixed bag.

Matthew: Beyond the Dubai and Abu Dhabi markets, how are you seeing the other countries in the Gulf region responding?

Garald: There's tremendous amounts of energy, enthusiasm in having the conversation around Smart, especially in Saudi Arabia. And it's going to be interesting to watch how the conversation matures. Because right now, we're seeing some good RFPs out there. We're seeing some good discussions. We're getting engaged in some good discussions on sort of district and city-wide levels, but it's just gonna be interesting when the rubber meets the road, and they actually have to pony up significant cash to actually realise some objectives. So I think it's a wait and see, but definitely we want to be part of that conversation.

Matthew: What do you think will be that tips them over the edge to just going from talking about it, to actually doing it?

Garald: I think once they find people that they actually trust, and that has gone on that journey elsewhere in the world, that can demonstrate the benefits of that journey in myriad and multitude of ways. I think once they're convinced, and once they have that relationship and trust, I think that will be the tipping point. Because once you have one big one that actually delivers it properly, everybody can come see it and it becomes tangible. So much of it right now, in a lot of clients' heads, is very theoretical and kind of mysterious. So I think anybody who can come in, that has a track record of delivery, a track record of trust, and can demonstrate that this has been delivered elsewhere, I think will be the primary engine for that catalyst.

Matthew: If somebody were to embark on doing a Smart project out here in the Middle East, what would your top tips be?

Garald: I think being pragmatic. I think not too pie in the sky. Start with something that's achievable. Start with something that has easily measurable returns. You know, a lot of the Smart stuff that's going on around the world looks at wellbeing, and happiness, and how people use a building and, you know, want to use a building, and I think that's great, but it's oftentimes a bit of a difficult thing to measure directly until you get to a certain scale. I think focus on the pragmatics. Focus on things that you have easily identified KPIs that you can measure against and show a clear return on investment. And focus on things that, and I know this is counter to innovation, but focus on things that have kind of been demonstrated elsewhere. So start there. And then, I think we can build that trust and relationship to expand to the more softer side of Smart.

Matthew: So be pragmatic. Get the brilliant basics right and be prepared for scale.

Garald: That's right.

Matthew: A big thank you to Garald Todd, Client Director for Property and Buildings in the Middle East. In our next episode we'll be focusing on a real-life Smart building that WSP has created, with Herbert Els.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

28 – Global Smart Workplace Strategy Project

Broadcast: 19/09/2019 (https://soundcloud.com/smart-thinking)

Editor: Matthew Marson

Guest Host: Nikki Hammer – Associate, WSP USA

Interviewee: Herbert Els – Senior Vice President, WSP USA

Matthew: This episode we've got a guest host, and it's Nikki Hammer. Nikki is an associate at the BOLDR Innovation Center in Colorado. As a project manager with 15 years of experience, she helps coordinate multidisciplinary WSP project teams to implement Smart Building solutions. Nikki is a professional engineer, and a LEED AP. And as part of her work at the Innovation Center, Nikki provides the opportunity for her clients to experiment with Smart buildings technology and evaluate real time data for their benefit.

Herbert: Smart isn't just technology. It is mechanical, electrical, lighting, sustainability, technology -- you want to pull in all these groups.

Nikki: You're listening to Smart Thinking, a podcast by WSP. I'm Nicole Hammer, taking you on a journey into Smart buildings. In this podcast we're talking about the Global Smart Workplace Strategy project that we developed for a multinational financial services company. Joining me here in the Boulder studio in Colorado is WSP's head of specialty services for the US Herbert Els. Herbert has pushed to drive our thinking outside of the traditional boundaries of our typical building engineering project. These forward-thinking projects, most notably the Good2Go project, have laid the foundation for the ThinkBOLDR Innovation Center. Welcome, Herbert. We've asked you to give some thought to one particular Smart project. Can you tell us about the project?

Herbert: I think one of the best projects to illustrate where we're going to in the future is really around strategic engagement. And the project that you mentioned, is a prime example of how we're changing our business model from not only doing engineering projects but really help our clients to strategize around what they should be doing long before there is an actual project. And it's really what excites me about this project specifically.

Nikki: So how did you get connected with the client to begin with?

Herbert: Interesting story. A lot of our clients are asking about: What is Smart, and why should I have a Smart building? And this particular client came to David Cooper at that time. And he found that the client was really interested in Smart, really wanted to know what's going on, and felt that an engineering firm would give them a real answer and not just a typical report but the real answer, and take responsibility for what this solution should be.

Nikki: So how did the scope of work evolve? What did it end up being that we actually did for this client?

Herbert: They wanted to really look at globally what they should think of in the future of their workplace. They are competing for talent, just like any other large firm today, very focused on energy improvements, where the cost savings can lie for them, really very hard measurable side of the story. We started introducing to them more looking at space, real estate space. We know open office environments that everyone is implementing these days, and then also their employee experience: How the solutions on the Smart side that they can implement that enhance the experience, but also makes their space at an optimum. So there's some real cost savings that they can measure on the employee side, not so easy to measure, but I think that's really, in the end, what made a big impact for them.

Nikki: Interesting. So it sounds like they were really trying to look beyond just the energy efficiency piece that we see so often.

Herbert: It took a while. Yeah, we got experts from our firm that cover nearly every discipline. I think that's important to understand. Smart isn't just technology. It is mechanical, electrical, lighting, sustainability, technology. You want to pull in all these groups. We brought them to the table, and we kind of did the same on their side where we brought stakeholders from the IT department, from management, from the real estate, and also find out what their roadmaps were. Because we wanted to make sure that their understanding, and this is their strategy, and they would have to make changes on their business and operational model to really implement the strategy. So it isn't just a report.

Nikki: Wow. It sounds very all consuming from the owner's perspective. What were some of the big hurdles and obstacles that you faced going through this process?

Herbert: I think it was exactly that. It's get everyone to buy into, spend time on it, really see it as an important part of their business. Obviously, making sure that they attain the strategy so they can adopt it in the end. That was probably one of the biggest things for us to overcome to keep them engaged in the project. I think we did an excellent job on that, and part of it is we got great feedback from the firm. And now I have a few follow up projects for them. And then they really wanted to see a way to truly measure what this outcome will be in the end of the day.

Nikki: In terms of finding ways to truly measure, was there any sort of new methodology or process that the the Smart building group created to measure results from this scope?

Herbert: I think to us, that was one of the most exciting pieces that came out of it is that with the help of our advisory services group, we were able to create a financial model. The client, being a financial firm, it was really important for us to really illustrate. And we were able to create a financial model that showed them return on investment across all three spectrums: on the energy saving side, on the real estate space side, and also on the employee experience side. And now we have that model, because that's one of the first questions most clients ask us when we talk Smart. 'Well that sounds, that sounds great, how much is it gonna cost me?' And really showing them on the operational side the return of investment, I think was the best outcome on this project.

Nikki: And I know I've seen some information on how we kind of layer a foundation with some future forward measures. Do you help them kind of roadmap through that process?

Herbert: Correct. Yeah, the road mapping turned out to be one of the things that they were really interested in. Not every client is willing to bite off the whole pie. And we helped them sift through what are the foundational elements that needs to be part of such a strategy that they need on their next project, and that they should have at a minimal in that project. And then eventually, how do they get to the end result, if there is ever an end result. I don't think it's ever an end. Smart is not on day one. The buildings grow in becoming Smarter. And so there has to be a continuous roadmap into what's next for them. And we lay that out for them too.

Nikki: Got it. Last question: You mentioned some next steps with this client. Is there any kind of new, or exciting opportunities laid out in those next steps that we're looking forward to working on?

Herbert: Yeah, we've actually since then got another project from them that we are going to help them with. And so we are continuing our engagement with this client because they're a very happy client at the moment.

Nikki: That's fantastic.

A big thank you to Herbert. It sounds like we've got a lot of great opportunities to explore new work, and new scopes in this space with clients in a very different and exciting way than business as usual. Join us for our next episode where architect Diba Salam from StudioDS, who invites us into the world of Smart Design.

Matthew: If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com.

Nikki: You've been listening to Smart Thinking, a podcast by WSP. I'm Nikki Hammer, and thank you for listening.

Smart Thinking Podcast

29 –Smart Design

Broadcast: 26/09/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Interviewee: Diba Salam RIBA – Founder, Studio DS

Diba: Really, Smart is how successful a space, a building, a design is for its inhabitants, and its community, and city as a whole.

Matthew: You're listening to Smart Thinking, a podcast from WSP. I'm Matthew Marson taking you on a journey into Smart buildings. In this episode, we're talking about how architecture and Smart are becoming more intertwined. I'm joined in the Dubai studio today by Diba Salam, principal and founder of StudioDS, an international design practice based in London, specialising in the field of architecture, interior design and master plumbing. Diba has extensive experience in the UK, Middle East and Southeast Asia supporting the RIBA as a member of the International Committee, and actively works with the UK Green Building Council on their research labs, and with the British Council on artistic and cultural engagement in the public realm. First question for you, if we jump straight in: What is a Smart Building, and why should we care?

Diba: Well a Smart Buildings is a building that can respond to a wider context, and a city's infrastructure. A Smart Building is responding to many things, but in order for it to be truly smart it should be able to connect and plug onto a platform which you can truly appreciate how a city is functioning. So for architects, what we really need to be thinking about, and it's not just the architects, it's the engineers, it's a whole collaborative team, but right from the onset when you're doing the actual concept, the feasibility, you have to start designing these components in, so that they're at least future proofed. Maybe the technology is not here right now, but it will be in the future, and these buildings need to respond to sometimes a 50, to even 100-year plan. And you know, let's hope those buildings last that long. And they need to be future proof, that's the key thing.

So a Smart Building is a building that is connected to its users. It responds to its users. It absorbs the information that how the users are using their spaces, and that's from an environmental, from a social aspect as well. The way in which buildings are responding at the moment. Sometimes a whole team are designing a building and actually the users don't know how to use that building. So if we said, for example, if a city, hypothetically speaking there's a Smart infrastructure in place, that building can connect into that platform. And we should be able to optimise the sustainable credentials of that building, and enhance them so that they're adaptive and effective over time, whether it's exposed ventilation systems, whether through a series of sensors for the lighting, whether it's through how, from a health and wellbeing perspective, how people are responding to their natural environment while they're working, where they're playing, how working environments are changing over time. You know, whether you should go for more, you know, hot desking rather than permanence.

Matthew: And do you think that the technology will help make a space more legible?

Diba: Yes, I do think so. I think technology, if we look at our smartphones right now, and how we're able to really enhance our way of life, because of the smartphone, and if buildings are more suitable for their users, and there is an education program and training program for people to actually understand how to use it, then yes it will be. But it does require investment upfront, but that investment for sure there'll be a return on that investment.

Matthew: Is that why we should care?

Diba: Absolutely. I mean, if we don't care, what we're basically saying is we don't care about the environment. And as sad, as corny as that sounds, we have to understand that the situation, and you can only look at London, how hot it got this year and how cold it was in the winter, climate change is impacting the way in which we're living in our cities right now. Cities are taking up a huge amount of greenhouse gases, and they only occupy something like 5% of the land, you know the Earth's land mass. So if we're looking at an urbanisation of our cities over the next 20, 30 years to almost in some places in Asia quadrupling, I mean it's incredible the statistics from the UN. If we don't consider those components, then you are throwing good money with the bad money, because just from an investment point of view, it will not be adaptable for the future. It will not meet your future needs. But also from in today's day and age where, let's face it, it's not easy taking on staff. You need to be competitive. So by saying you don't care about that, you're saying you don't care about where you live, who you're employing. It's far more complex. It's far more complex social issues there to take onboard.

Matthew: How do you see architecture and Smart?

Diba: Well, Smart and architecture, we always use the terminology Smart Design. And there's this impression that Smart is about technology. And the debate, the discussion is always dominated by that. Really, Smart is how successful, a space, a building, a design is for its inhabitants, and its community, and city as a whole.

And in order to design that kind of success into the process, you have to use a series of tools. And technology has allowed us through, say for example, virtual reality, to really engage and communicate the design to, you know, to the people, all the stakeholders, whether it's, you know, your, you know, a school, or whether it's, you know, the actual client who's paying for it. That's absolutely essential.

And also, when you look at the technology side, of course, that's what's taking it into a different dimension now. That space needs to have that true function that it can create the space for, you know, whether it's a series of events, or whether it's just a contemplative space, actually it can respond to the technology that's available at the time, or the technology is not available, but it needs to be future proof. So how are we making sure that our buildings are future proof is essential in the debate right now.

Matthew: So that's really interesting. Do you think that Smart is the logical progression of an architect's drive for human centricity?

Diba: Yes, I do think so. I think we're living in a time where technology is moving at an incredible pace, and yet architecture and the process of construction is still kind of slow. You know, we are, it is complex building large objects occupying a large piece of space in a city.

When you look at how the smartphone has created a really interesting user experience, it's given us more power to our own experience now, and there's no reason why that experience should not be extended to how we experience spaces, how we experience, you know, coming into a building, how we experience approaching that building, how we experience, you know, being in that building and understanding what to do in that building. And, you know, so that's from a very personal touch now where users feels more competent to be able to exercise his interest in what he wants to do, he or she wants to do.

And I think architects have always been trying to create moments and experiences that are memorable, and that the lasting impression, and inspire, and we need to get back to that point where we're designing for, you know, our people, for the communities. And I think, Smart is an excellent tool to allow us to do so.

Matthew: If someone wanted to create some Smart architecture, what would your top tips be?

Diba: The way I start designing, I want to understand exactly what are the key criterias at the briefing stage so that I can ensure that once I want to go into the more creative parts I'm not compromising anything that will make non-performing. If, say for example, we start with regulation: What are the regulatory requirements for that particular locality? And regulation isn't just a series of: Oh, I have to read off a list of criteria. It could be actually future aspirations for that city. And it's essential that security is at the heart of, you know, there's a lot of information that you can glean from Smart buildings, and that should be confidential. And it's important that the people who are going to be occupying that space have that confidence that that is put in place. It could also, and that leans on the aspirations then of, whether it's developer, whether it's an institution, a government that's, you know, developing maybe schools.

Matthew: They've got very different budgets.

Diba: Exactly. There'll be very different budgets. When you look at, say, The Edge in Amsterdam, when you look at Bloomberg in London, these are Smart buildings, and they're very responsive buildings. But, you know, they've had a pretty amazing budget to work to. And it's great that we've got developers who are willing to invest in that. But if you're, say for example, a school, and you've got limited budgets, but you have great aspirations for ensuring that the building is future proofed, then, really, you do need to make sure that whatever components you're putting in place have the ability to serve technology well enough. And I have to say, it's really important to understand that security aspect as well.

Matthew: A big thank you to Diba Salam, principal and founder of StudioDS. Join us in our final episode when we summarise all the content that we've covered over the past six weeks and draw out those all-important conclusions.

If something in this episode has piqued your interest, then have a chat with us. Email: Smart@WSP.com. You've been listening to Smart Thinking, a podcast, from WSP. I'm Matthew Marson, and thanks for listening.

Smart Thinking Podcast

30 – Round Up

Broadcast: 03/10/2019 (https://soundcloud.com/smart-thinking)

Host: Matthew Marson

Expert: There's a lot of debate about what a Smart Building is these days, and lot of, I'll call it, snake oil out there.

Jonathan Jones: Databases are dead. Enter the Blockchain.

Milesh Patel: [A Smart] Building is a building that tells you what it's doing.

Miguel Sosa: We even connected weather sensors, Matt, weather sensors.

Julie Alexander: Very much about connectivity.

Tom Hollis: This is about making your work more like your life.

Matthew Brittle: You know, we're behind closed doors. We're a bit of a black art.

Nick Offer: A Smart Building is a building that comes to life.

Matthew: Hello, and welcome to our grand finale. Yes, we finally got there. And with over six hours of insights from experts from around the world, what a journey we've been on. We've had some highs.

Harry Knibb: I'm interested in Smart healthy buildings simply because I think they've got a fantastic opportunity to make us happy.

Matthew: And some lows.

Expert: Mobile software...

Matthew: ...and I've lost it. Sorry.

Expert: You were going so nicely too.

Matthew: Proper BBC, this.

Matthew: We've had some surprises.

Miguel Sosa: I've worked in many buildings, as I'm sure all our listeners have.

Matthew: And some predictions.

Chlump Chatkupt: I don't like to predict.

Matthew: You need the data.

You're listening to Smart Thinking, a podcast by WSP. I'm Matthew Marson taking you on a journey into Smart buildings. In this episode we're going to condense our journey into a series of pitstops, taking you through what we believe is our story of Smart buildings. So, let's begin.

Have you ever thought about what a Smart Building is? What it can do for the people that are in that building? How can it be transformative for your business? Definitions are wide-ranging, and it means so many different things to different people.

Steve Jarvis: Smart and intelligent buildings are enhancing or supporting the demand of users in these spaces.

Matthew Brittle: It's something that's actually sort of, I suppose been engineered and thought about in a way to begin with, that reduces the vulnerability of security incidents or potential security incidents occurring.

Diba Salam: Well a Smart building is a building that can respond to a wider context, and a city's infrastructure.

Matthew: How can it be transformative to your clients' business? Tom Smith meets many clients in every region in which we work, and again and again it keeps coming up as one of the clients' top concerns.

Tom Smith: This reminds me of sustainability probably 20 years ago. Sustainability was a new concept and it took quite a while for clients to be able to grasp that and understand the value that sustainability can bring to their buildings, and how it can improve the performance of buildings.

Matthew: We've helped clients' strategy.

Herbert Els: We wanted to make sure that they understand in the end this is their strategy, and they would have to make changes on their business and operational model to really implement the strategy. So it isn't just a report.

Matthew: We've looked at Smart in terms of the workplace.

Steve Jarvis: You're going into meeting rooms, the tech, the people using a meeting space. We recently measured this for a particular client who, on average, spent 15 minutes getting the IT and the AV working in each meeting room before a meeting. When they have over 900 meetings a month, that's a pretty, yeah, a pretty big drain on their productivity.

Matthew: As a Smart healthcare facility.

Kevin Cassidy: You know, improving the patient outcomes, which I suppose is part of the experience, if you can track things, if you can measure things, and you have the data, you can then learn from your mistakes and make the next experience, or the next treatment for a patient be that much better.

Matthew: And as a Smart stadium.

Jay Wratten: Why go to the game, right? The TV coverage is great. And so as we're designing stadiums, what we're trying to find out is: How can we design them differently to make people go to games?

Matthew: And we looked at how the property developers' business models could be revolutionised by Smart.

Jay Wratten: What is the revenue model, and what what are you actually selling, right? So a building generates data. And how can a developer create a revenue stream out of the data that they're generating?

Matthew: One thing's for sure, everyone's agreed that a Smart Building starts with people. And as designers, we need to focus on a human-centred design approach.

Miguel Sosa: The building itself is playing a living, breathing role in bringing together people who are able to share ideas more quickly, feel that their needs are being met, and are having fun. That to me was success, the fact that we could attract talent, who otherwise would have picked other companies had it not been for that building. That to me was fantastic.

Matthew: That's Miguel Sosa. Another key takeaway on digital service design is from Tom Hollis, our guest in episode six.

Tom Hollis: And what I think underpins particularly our interest in design at the moment is really the dogged, absolute True North of the user. Everything is built around what the user wants, how the user wants to do it, to what intent, or what ambition the user is trying to get to it, and how we can help them achieve that.

Matthew: But what does digital actually mean for our designers? How can we be at the forefront of technology and the changing landscape of engineering? Nick Offer explains.

Nick Offer: I think there's an awful lot about to change, and I think we've already started. The first thing we're beginning to do is understand that it's changed around us, that buildings are gonna be automated. The buildings are going to need to be run and designed differently. And we're also beginning to see that we need to design them differently ourselves. We're beginning to automate our process.

Matthew: We discovered how Smart can measure and enhance productivity, provide extremely valuable location services, and create communities within the building. But to do this, we need to get down to the techie bit. AI specialist Chlump Chatkupt, and Henry Okraglik explore AI and Appification.

Chlump Chatkupt: Oh, well, as celebrated AI scientist Andrew Ng observed, AI is the new electricity. AI will become increasingly foundational, transformative, and pervasive.

Henry Okraglik: It's also very expensive kitting out a building to be Smart so that we can interact with it. So you want to be very sure about why you're doing this and what you're trying to achieve, and not getting too caught up in the hype and the possibilities.

Matthew: Just when you thought it was safe to create a Smart Building, two overarching concerns surfaced: Security and ethics. Here's Matthew Brittle from WSP.

Matthew Brittle: Yes, it disrupts things because it gives us another sort of threat vectors where people can attack. But actually that's the same as anything. We're just creating the mitigations and the management sequences that go with that, to go alongside the technology.

Matthew: And Conor Clarke brings us back down to humanity.

Conor Clarke: What a Smart Building is, fundamentally, is a building that can make decisions, that can make choices about the environment. And those choices might have ethical dimensions to them.

Matthew: Everyone's Top Tips aligned with the concept of outcomes first. Tech should never be used just for tech's sake.

Jane Richards: First of all, to just step back and ask a bigger question.

Kevin Cassidy: What do they want the building to do? If it is a quote/unquote Smart Tool, what are the goals you're actually trying to achieve?

Nolan Rome: I would engage your user base and the people that are going to be served and benefit from that.

Julie Alexander: It's really getting down into the nitty gritty of the day to day problems that the frontline staff are tackling.

Matthew: For us, the formula is simple. We call it Smart Simplified: integrating technology, purposeful design, and actionable data equals optimal managed performance and happier, healthier users.

Matthew: And finally, something that stood out for me is what smart means for architects. Here's Diba Salam from StudioDS.

Diba Salam: When you look at how the smartphone has created a really interesting user experience; it's given us more power to our own experience now. And there's no reason why that experience should not be extended to how we experience spaces.

Matthew: This has been a production by the global property and buildings marketing team. In particular, big thanks to our producer Nicola Evans, digital marketing executive director Caroline Boule, Assistant Editor Liam McCarthy, Feelgood Creative for our graphics, and executive sponsor Julie Guppy. Also a big thanks to our sound engineers Casual Films, and to all of our interviewees, and of course to you, our listeners.

If something in this episode has piqued your interest, then have a chat. Email Smart@WSP.com. You've be listening to Smart Thinking. I'm your host Matthew Marson turning off the mic for the last in this series. Thanks for listening.