Changing Societal Expectations and the Need for Dynamic Asset Lifecycling and Obsolescence Management

Kieran Mulholland[1], Michael Pitt[2] and Peter McLennan[2]

[1]CEG Engineering School, University College London, England
[2]Institute for Environmental Design & Engineering, University College London, England
Email: Kieran.Mulholland.13@ucl.ac.uk

Abstract

Current revolutions within the consumer electronics market are having dramatic effects upon how businesses are able to deliver their services with the continued embedding of technology within our lives. Conversely, this is currently having a direct impact upon long life assets with life expectancy in the region of 15+ years, an impact, which is believed to only increase. The term asset in this context refers to systems and their internal components, for example security systems and their orthogonal components i.e. intruder detector components, CCTV cameras, recording equipment, automated security doors, controls etc. This is a rather middle to top-level view upon the term asset and components; you will find literature referring to components as the individual electrical and material elements of a product. The mismatching of lifecycles due to contrasting market conditions is driving unforeseen obsolescence investments across the Built Environment, highlighting the current neglect of obsolescence within static asset lifecycle planning. As society changes, so do the expectations of service delivery from the Built Environment. The pressures imposed by these changes upon Facilities Managers will demand resultant changes in how services are delivered, maintained and supported throughout their useful lives. It is the combination of societal demands for a greater connected, interactive and smarter Built Environment and the effects of technological change upon obsolescence that will be covered in this paper. This paper will build upon a current Engineering Doctorate project into obsolescence and asset management to speculate both the importance of developing a dynamic approach to planning asset lifecycles and possibly how this would materialise in the future. Evidence will be provided in the form of a case study, reviewed literature and current live trends, supporting the title of this paper. The main conclusions include the growing evidence that what is being witnessed across the Built Environment will likely increase and also that more advanced industries have experienced the same problems previously. It is therefore seen as a growth area for the Built Environment to reduce the impact of obsolescence and ensure that service delivery continues to meet societal expectations.

Keywords: *Asset Management, Lifecycle, Obsolescence, Service Delivery, Facilities Management*

1. Introduction

Since 1965 when Gordon Moore first speculated about the future trend of computational power, Moore’s Law, technology has continued to support this original foresight (Mack 2011). Regardless of the readers’ views upon privacy, data, statistics and the like, there is a wealth of literature both within the main stream circles and academic journals, illustrating the dramatic change we are all experiencing and the plethora of change to come. Every day in 2015 over 75% of UK adults use the Internet, for a variety of needs, with almost 100% of them using it ‘on the go' (Office for National Statistics 2015). These two statistics are more than double the uptake of 2006. Similarly, an independent report produced by the World Economic Forum in 2015 identified from a survey of 800 executives and experts, from the ICT sector, that by 2025 the first 3D printed production car would be on the road and the Built Environment would encapsulate 1 trillion sensors connected to the internet (World Economic Forum 2015). Much of the above can be found within literature associated with the term the ‘Internet of Things (IoT)’. IoT is founded upon the increasing computational power and reduction of cost and size of sensor technology (Moore’s Law), making the embedment of such technology financially viable on a large scale. In addition to the trends and developments made within industry, there are social implications of such change, Michael Felton of the New York Times created the diagram in Figure 1, which demonstrates the rapid increase of technology adoption in American households. This powerful illustration shows not only how technology is quickly finding itself within the home, but also how once a new form of technology has become accepted it quickly saturates. Technology trends such as the IoT offers a wide variety of benefits for both building occupants, through service delivery, and Facility Managers through data collection and analysis (please see Big Data, Predictive Analytics and Machine Learning).

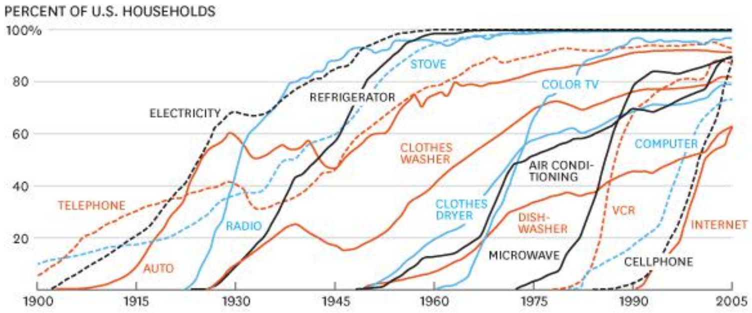

Figure 1 Technology Adoption within American Households, adopted from Felton (2008)

Gravier & Swartz (2009) described another side to the above trends and coined it ‘the dark side of the technology curve’, within which it was highlighted that obsolescence and lifecycle mismatches would carry significant operational and financial costs. Obsolescence occurs when a component or asset is no longer suitable for current demands or is no longer manufactured or supported. Obsolescence is not a new term, phenomena or problem, however in light of the above trends it is tipped to greatly effect the Built Environment in the same way it challenges the Oil & Gas, Avionics, Aerospace and Defence industries. This paper will draw upon new findings from a case study experiment, illustrating the cost of ‘the dark side of the technology curve’ within the Built Environment.

2. Literature Review

The following section will cover two key themes; recent trends around the IoT and the changing expectation of service delivery within the Built Environment, regarding asset obsolescence. The purpose being to capture the future changes that will effect our buildings and how we deliver services, and also the wider implications/demands upon lifecycling techniques and standards.

Depending on whether you reference MIT Technology Review, International Data Corporation (IDC) or business consultancy firm Gartner, forecasted projections of 28, 32 or 33 billion connected devices will exist by 2020 (SIEMENS 2014). Such an expansion of devices, both producing and collecting data, will become inevitably wide reaching. Google trends currently illustrate distinct search patterns, telling a story of how large sections of society are becoming actively aware of the IoT, shown in Figure 2.

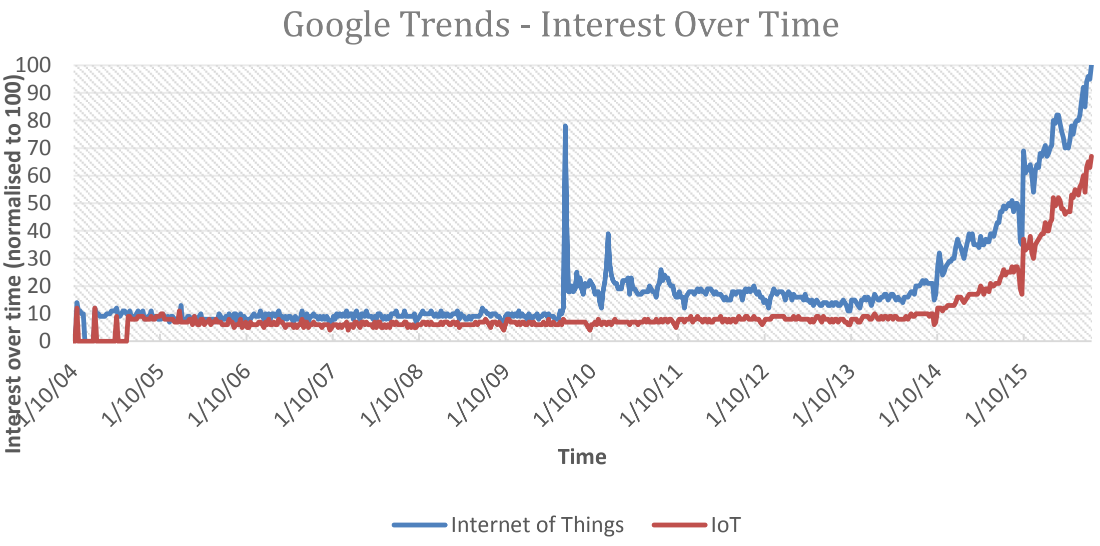

Figure 2 Google Trends for the terms 'IoT' and 'Internet of Things', publically available data from www.google.co.uk/trends/

In light of the above figure, it is felt by this author that such trends will effect society in both an active and passive way. Meaning, we as members of society will either actively adopt new services, now possible through big data analysis and the medium of smart phone applications for example. Alternatively, lives of some sections of society, will passively be effected by efficiencies, now possible through discrete optimisation modelling and data driven decision making, traffic flow for example. Ultimately however, as we have witnessed with the adoption of smart phone technology, once the concept has been accepted, it quickly becomes expected. Therefore, whether you actively or passively partake in the trends outlined within this paper, subconscious acceptance of new performance levels of service delivery is likely.

The above theory, aligns with the views of ‘mutual shaping’ with regards to ‘social shaping of technology (SST)’, where society and technology development are not independent of each other but rather influence and shape each other mutually (Williams & Edge 1996; MacKenzie &

Wajcman 1985). This is a contrasting view to the previously followed technology determinism views upon technology development, heavily associated with Karl Marx. SST directly tackles the conflict between technology development, in this context relating to the IoT, against societal values and expectation, in this context relating to privacy and service delivery expectations. Does technology development shape society? Or conversely will society shape the development of technology? Interestingly, Williams & Edge (1996) explain how the concept of SST involves the idea of ‘choices’ (though not necessarily conscious choices), meaning in a ‘mutual shaping’ context, society will consciously and subconsciously effect and be affected by technological change within the Built Environment.

In 2014, SIEMENS as part of their ‘pictures of the future’ magazine, reported that the Asia Pacific region were investing more into the IoT than Europe or North America, shown in Figure 4 (SIEMENS 2014). This mirrors the analysis undertaken by Google, in Figure 3, showing that six of the top seven countries searching for information regarding the IoT are from the Asia Pacific region. The result of such activity has led to these areas also holding both the largest number of and fastest growth rate of patents related to the IoT, typically linked with organisations such as LG Electronics and Samsung (LexInnova 2014).

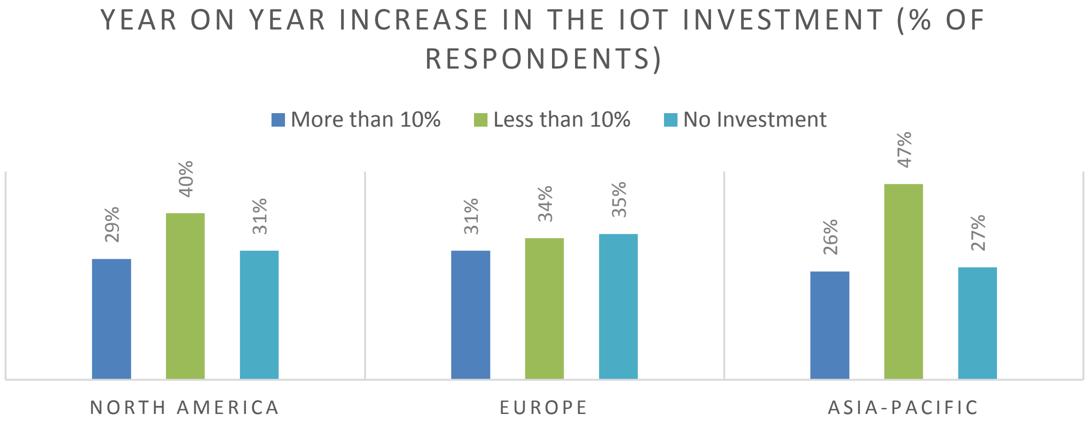

Figure 4 Year on year increase in IoT investment, percentage of respondents within report, adapted from SIEMENS (2014)

South Korea	100
Taiwan	87
China	68
Singapore	33
Hong Kong	29
India	29
Italy	24

Figure 3 Google Trends of the terms 'IoT' and 'Internet of Things', publically available data from www.google.co.uk/trends/

The IoT is on course to disrupt and revolutionise the performance of FM service delivery, currently being capitalised by organisations located from the Asia Pacific region. This will inevitably effect society in both our professional and personal lives, potentially changing our expectations of service delivery within the Built Environment. There is academic and industrial evidence supporting the above relationships, however whether they are causal is yet to be clearly understood, therefore the real impact of such change upon both service delivery and society, is not well defined. This paper will now draw the readers' attention to the other side of the above trends covered within this literature review, focussing on obsolescence and the life sustainment issues created by lifecycle mismatches.

Obsolescence occurs within assets when they are no longer manufactured or supported, this occurs in both software and hardware, recently exacerbated by the explosion of the consumer electronics market and the resultant shortening of lifecycles (Feng et al. 2007; Solomon et al. 2000; BSI 2007). Solomon et al. (2000) produced Figure 5, which conceptually introduces how both obsolescence is inevitable and also time related. A single asset, or collection of assets within a system, will contain hundreds and often thousands of components, which will contain their own lifecycles. The length and profile of these respective lifecycles are dictated by market forces and manufacturers. This unknown characteristic of assets within the Built Environment, creates lifecycle mismatches, causing supportability issues for FM and building users. This predominantly unrecorded, side effect of technological advances was coined as 'the dark side of innovation' by Gravier & Swartz (2009). The case study featured within this report begins to quantify the scale of the impact of the aforementioned dark side. A bibliometric analysis, shown in Figure 6, illustrates the rising research attention towards obsolescence. However, following gap analysis it was identified that consideration for the assets found within the Built Environment, and end users as opposed to manufacturers receive little attention.

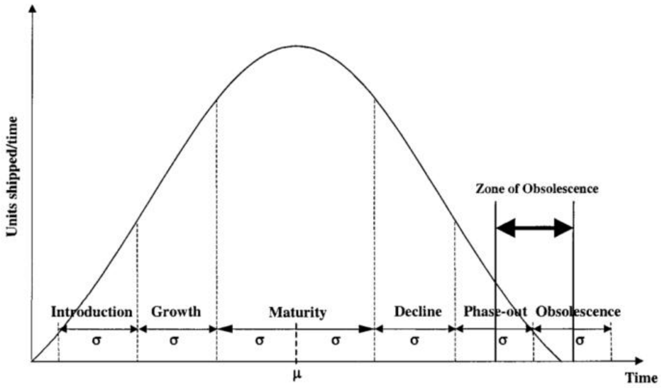

Figure 5 Obsolescence lifecycle stage, from Solomon et al. (2000)

The crux of obsolescence within assets, is the dependence upon life expectancy of assets and their components and the need to lifecycle cost the projected intended life the asset. This is further complicated by the BS ISO 15686-2:2012 for Service Life Planning of Buildings and Constructed Assets containing the following caveat:

“[Lifecycle Planning] ... does not cover limitation of service life due to obsolescence or other non- measurable or unpredictable performance states.” - (BSI 2012) Service Life Planning

It is common practice to provide a nominal figure in years for the expected useful life of assets and major components, this prescriptive approach and has proven to be sufficient. This paper will challenge the applicability of such stationary methods for assets and asset systems that now experience dynamic variations of lifecycles and life expectancy as markets change at a faster rate.

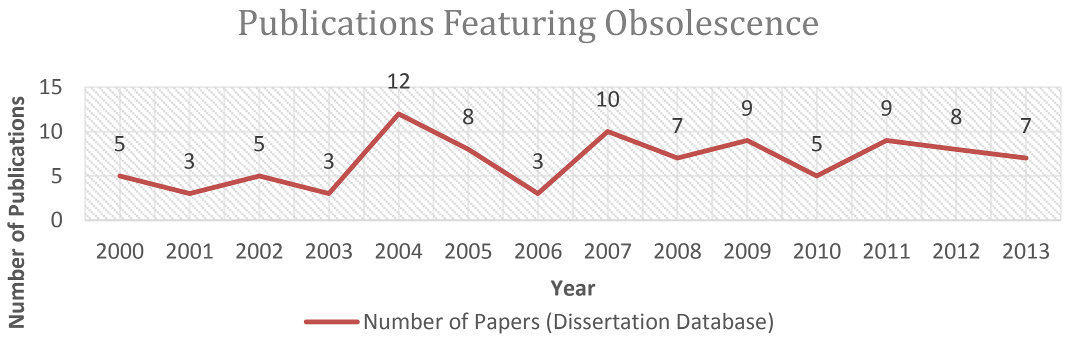

Figure 6 Bibliometric Analysis of Literature featuring keyword search: Obsolescence

In summary, there is evidence suggesting that the Built Environment as we know it, is to become digitised in the coming decade with an abundance of new data streams being created. Service delivery will experience dramatic improvements through the adoption of smart data analysis, providing tailored services to increase satisfaction of building users. Once wide spread, this is likely to become accepted as the norm and therefore a change in societal expectations upon service delivery by FM. In order to keep up with this trend and adopt further technology within our buildings, the effects of obsolescence are likely to increase, impacting both operationally and financially upon FM. It is logical, to therefore extract a need to improve obsolescence management techniques in tandem with ‘dynamic’ lifecycle methods to mitigate these effects both more precisely and strategically.

3. Research Design

This paper has adopted a case study design, using a UK based PFI funded London office building, which has a 100,000 m^2 foot print. This particular PFI was a refurbishment contract and the case study investigates into the effects of obsolescence into key long term asset systems. The time frame featured within this paper spans from 2010 to 2015, a decade on from practical completion of refurbishment works. A quant point to note, as the average life expectancy of software will predate this case study, whilst the ‘mother’ systems will require sustainment through and beyond this study.

Following discussions with the PFI contractor regarding historical procurement patterns and knowledge from the literature review, it was suggested that the following three systems be considered for this case study:

- Fire Alarm System
- Security System
- Building Management System

Historical purchase orders were analysed to investigate the pattern of investments, against the pre planned lifecycle expenditure for these systems. Specifically, any lifecycle investments associated with obsolescence were also extracted to begin formulating evidence to the scale of impact of obsolescence within this case study.

Further to the above data, meetings were held with the respective organisations involved within the supply and maintenance of the above systems to explore additional context. This qualitative element of this paper, adds to the numbers that feature within the discussion section.

In summary, it was felt a PFI funded piece of infrastructure was an appropriate case study, as it provided unparalleled access into commercial information, which if resided within the public sector would unlikely we available. PFI contracts also provide a set of constraints and drivers to optimally operate asset systems, whilst strategically planning their lifecycle replacement, creating further incentives for all stakeholders to understand the impact of obsolescence further.

3.1 Case Study Evidence

Figure 7 is a lifecycle budget for the case study site, spanning from 2005 to 2015, illustrating the annual planned expenditure to replace assets in a prescriptive manner. This projection, naturally is management by an Asset Manager and the profile can change if there are both unexpected failures of assets and unexpected expenditures. The highlighted bars show the focus of this case study, the period 2012 to 2015, where the three case study asset systems were investigated. Note, the profile of the lifecycle expenditure and how in the year 2013, around a decade on from refurbishment, considerable investment was planned. Whilst this has logical

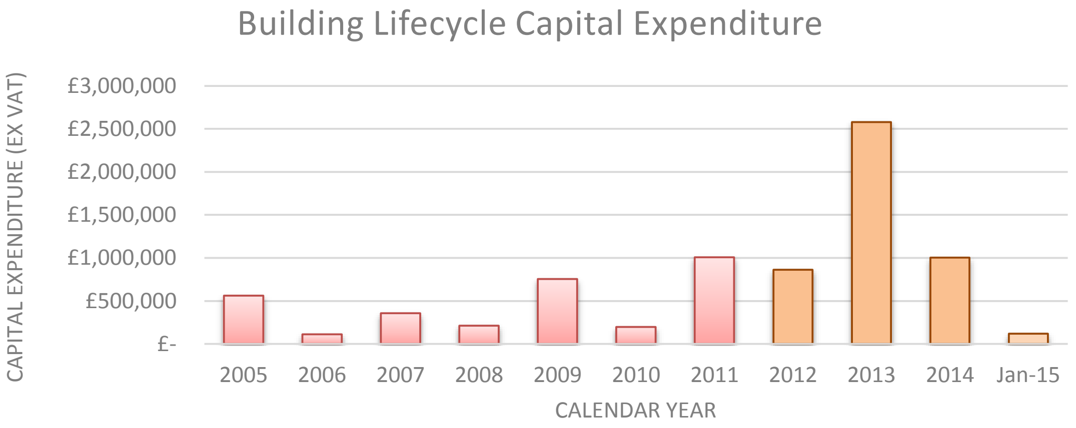

Figure 7 Building Lifecycle Capital Expenditure, across length of PFI to date

narrative, it is not data driven and it is not dynamic. The efficiency of a lifecycle fund is reliant upon the competence of the Asset Manager, and their ability to reactively reorganise programmes of replacement to offset costs.

In order to investigate the current impact of obsolescence driven investments, a snapshot of the time frame 2012 to 2015 was taken and then illustrated in Figure 8. As you can see across this short period there were considerable investments related to obsolescence (~ £1.5m). Note, it is not solely the financial size of these investments which can pose a problem for lifecycle management, but the unforeseen nature of the majority of these investments. Requirements that did not exist prior to their identification can put pressure on FM and the operational business of service delivery. Evidently, there are financial drivers to research into the management of obsolescence and lifecycling techniques, however, it is the operational impact in life critical environments i.e. major hospitals that prove to be the overriding driver.

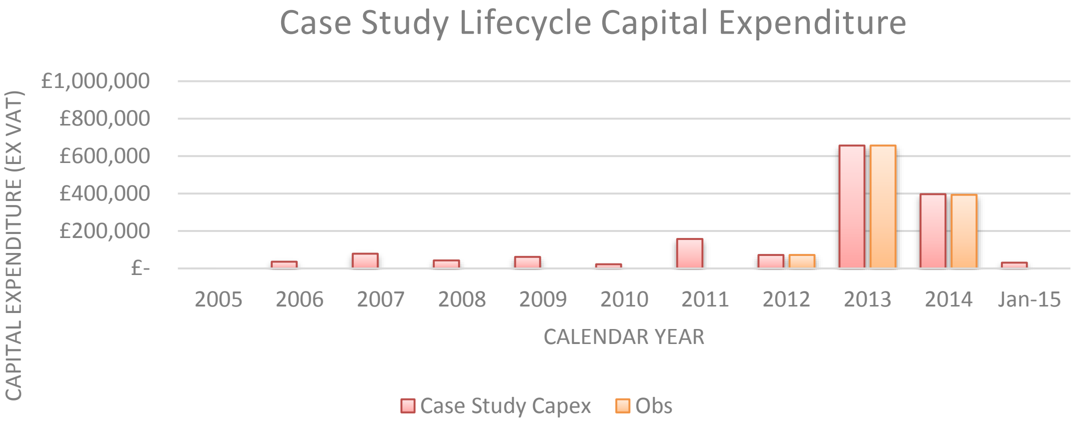

Figure 8 Case study comparison of obsolescence related investments and individual lifecycle expenditure

Mining the data further, two things were discovered; firstly, within the case study asset systems 10 years on from installation, 90%+ of the annual lifecycle expenditure was driven or associated with obsolescence, shown in Figure 8. Evidence that the effects of obsolescence may be cyclical

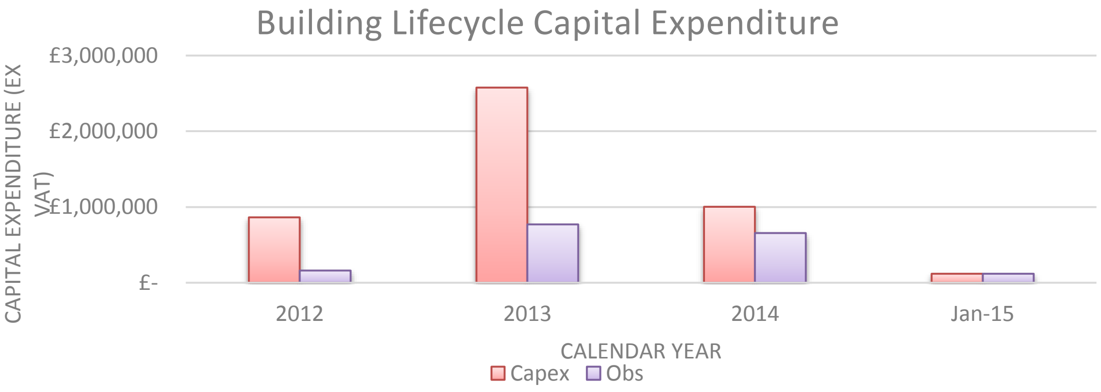

Figure 9 Case study obsolescence associated investments compared to total lifecycle expenditure for entire site

in behaviour. Figure 9 illustrates the total annual lifecycle expenditure across all systems, across the same period, 44%, 85% and 60% of the expenditure related to obsolescence was found within the three case study systems. Evidence, that the 80:20 rule is likely to apply, important when seeking to strategically manage obsolescence within the Built Environment.

In summary, the evidence provided by this case study have speculated that obsolescence may behave in a cyclical fashion, occurring in a repeated manner. Also, the Fire Alarm System, Security Systems and Building Management System are likely to concentrate your obsolescence driven investments and if only limited resource are available, to focus them on these assets. Finally, there is sufficient evidence to demonstrate that obsolescence is effecting the Built Environment currently and if managed reactively, can create significant additional lifecycle expenditure, which can cause both operational issues and lifecycle management issues.

4. Discussion

In the UK BS 8544:2013 for ‘Guide for life cycle costing of maintenance during the in use phases of buildings’, is widely used, it details the methodology for lifecycle costing (LCC) of maintenance for in use phase assets (BSI 2013). The methodologies encompassed by this British Standard, whilst comprehensive have two fundamental weaknesses. Firstly, due to their prescriptive nature, the effectiveness of LCC is dependent upon the competence of the individual performing the methodology and their respective experience and knowledge. In practice, it is common for this individual to change over time and for information sharing or continuity planning to fail. Secondly, the information gathered in the ‘capture stage’ of asset LCC must remain ‘live’ or dynamic in order to be applicable to the real world situation. In practice, it also not uncommon for this requirement to not be robustly implemented, therefore classifying the data being used for LCC obsolete or out of date. However, a competent and experienced Asset Manager may still posses the knowledge required to effectively manage assets through their lifecycle, maintaining their operational status.

This paper draws upon several major trends that when implemented will drastically shorten the lifecycle of many, previously long life, asset systems. This shortening will encourage obsolescence and reduce the time available to manage and plan asset maintenance. These aforementioned forces, will require a more dynamic approach to LCC, that is more flexible to sudden changes in market conditions, deeming specific component(s) obsolete, effecting useful life supportability.

The case study that features within this paper highlights how, within one example, current Asset Management practices are failing to avoid obsolescence driven investments. This has driven additional lifecycle costs and also applied short term operational risks to the organisation. Ultimately, this paper seeks evidence to suggest that the current practice for LCC should be readdressed, in order to avoid what Thomsen et al. (2015) label as ‘obsolete buildings’; where building demands have changed and service delivery has failed to adapt. A recent example of the impact this can have upon the Built Environment could be, the changing buying behaviours of UK supermarket shoppers. The Financial Times reported that British Supermarkets are to write off billions of pounds from the value of their supermarkets, due to consumers shifting their preference to smaller outlets and online shopping, deeming the large style supermarket as a business model obsolete (Grover & Grover 2012).

4.1 Need for Dynamic Lifecycling

The term ‘dynamic’ in this paper refers to a method that is flexible and adaptive to characteristic changes. For example, a LCC method that considers obsolescence throughout the useful life, proactively monitors performance and condition deterioration, whilst amending the expected life and lifecycle replacement strategy would be considered flexible. In other pieces of literature this type of decision making model, have been described as ‘data driven’ as opposed to an ‘expert system’.

Academic literature by Bradley & Guerrero (2008), Sandborn (2013), Feng et al. (2007), Gravier & Swartz (2009) and many others, all suggest that the impact of obsolescence is only going to increase. These thoughts were echoed by those decision makers within the aforementioned case study, who were witnessing it’s effects first hand. If current methods remain stationary, whilst the trend of obsolescence risk increases, then the shift to meet growing societal expectations in the future will be a costly one.

Finally, to illustrate the possible future impact of obsolescence driven investments within the case study that features within this paper, Figure 10 was created. To create Figure 10, an assumption was made on the behaviour of obsolescence within long life asset systems, that lifecycles of components within systems across a building were so miss-aligned that obsolescence driven investments would occur on an almost annual basis in various systems. This would be represented on a lifecycle budget projection as a random/constant percentage of the annual expenditure. In order to project these percentages, the case study profile was extrapolated across the remainder of the PFI contract and visualised as a percentage of the actual planned lifecycle budget for this building.

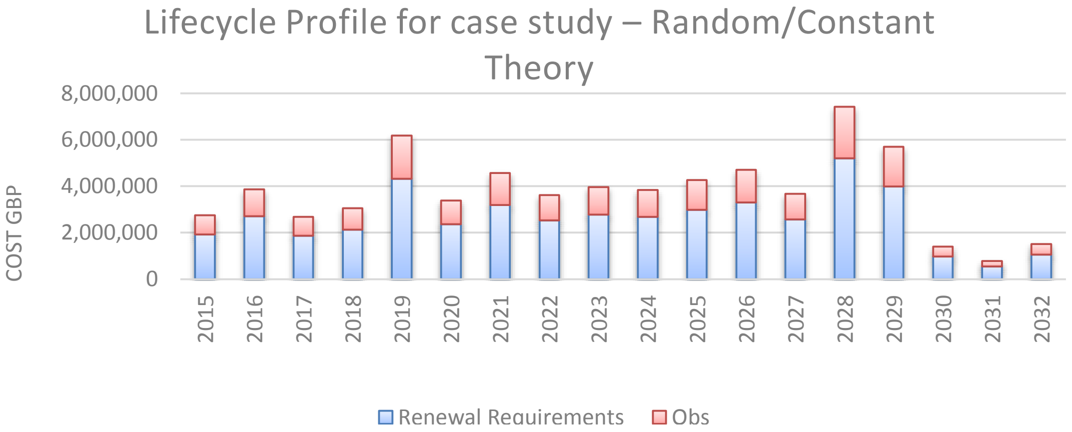

Figure 10 Extrapolated future obsolescence related investments as a percentage of planned Lifecycle expenditure for remainder of PFI

The accumulative investment associated with obsolescence for this single PFI contractor is potentially staggering. By 2032 an additional total of £20 million could be assigned to obsolescence related investments. Note, what this projection does not account for, is whether these investments are in addition to the current lifecycle planned expenditure or inclusive. This is unknown due to the timing of an obsolescence driven investment, which will massively impact an Asset Manager's ability to offset other planned lifecycle expenditures to keep the annual within budget.

5. Conclusion

To conclude, we refer back to the title of this paper 'changing societal expectations and the need for dynamic asset lifecycling and obsolescence management' and cover the key trends and points made.

In 2015 now more than half of the planet now live within cities, creating a dense urban environment. Researchers across academia and industry are both seeking to implement new technology to create new methodologies for service delivery across the Built Environment, in a way that previously was not possible, advances in this area come under the umbrella of the IoT.

History has shown us that whilst it is unclear whether society shapes technology, or vice versa, it is clear that as soon as technology is commercially accepted, it quickly becomes expected. It has been speculated within this paper that when FM actively embraces the IoT and provides new levels of service delivery, building occupants will quickly adopt and expect a consistent new service level.

The IoT has the potential to improve service delivery in almost every context, however this paper dives deeper into the 'dark side' of technological advancement and the cost of obsolescence when seeking to support asset systems within the Built Environment. Connected to obsolescence are the current LCC methods, which have proved to be sufficient in modern construction. The case study that featured within this paper has provided some evidence that the cost associated to obsolescence is significant and growing. The reactive manner in which obsolescence is currently managed and its current separation from the LCC methodology, has created a demand for a more dynamic approach, which is likely to be more data driven. This paper features some work from a current Engineering Doctorate research project, which is developing and testing data driven decision and risk tools for mitigating obsolescence.

Finally, whilst this paper illustrates a single case study which may not be homogenous across the industry, if academia is to be believed and the risk posed by obsolescence is only to increase and the industrial research on modern trends are to be believed. Then we need to adapt our methods now, in preparation for the changes we are all going to witness in both our personal and professional lives.

6. References

Bradley, J.R. & Guerrero, H.H., 2008. Product Design for Life-Cycle Mismatch. *Production and Operations Management*, 17(5), pp.497–512. Available at: http://search.proquest.com/docview/228681941?accountid=14511.

BSI, 2013. *Guide for life cycle costing of maintenance during the in use phases of buildings*, London BS 8544:2013.

BSI, 2007. *Obsolescence management — Application guide*, London BS EN 62402:2007.

Felton, M., 2008. How Americans Spend Their Money. *New York Times*. Available at: http://www.nytimes.com/imagepages/2008/02/10/opinion/10op.graphic.ready.html [Accessed October 22, 2015].

Feng, D., Singh, P. & Sandborn, P., 2007. Lifetime Buy Optimization to Minimize Lifecycle Cost. *Proceedings of the 2007 Aging ….* Available at: http://www.enme.umd.edu/ESCML/Papers/AgingAircraft07-LTB.pdf [Accessed January 30, 2014].

Gravier, M.J. & Swartz, S.M., 2009. The dark side of innovation: Exploring obsolescence and supply chain evolution for sustainment-dominated systems. *The Journal of High Technology Management Research*, 20(2), pp.87–102. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1047831009000194 [Accessed February 11, 2014].

Grover, R. & Grover, C., 2012. Obsolescence - a cause for concern? *Journal of Property Investment & Finance*, 33(3), pp.1–9.

LexInnova, 2014. Internet of Things: Patent Landscape Analysis. *World Intellectual Property Organisation*. Available at: http://www.wipo.int/export/sites/www/patentscope/en/programs/patent_landscapes/documents/internet_of_things.pdf [Accessed November 20, 2015].

Mack, C. a., 2011. Fifty years of Moore's law. *IEEE Transactions on Semiconductor Manufacturing*, 24(2), pp.202–207.

MacKenzie, D. & Wajcman, J., 1985. *The social shaping of technology*, Open University Press: Buckingham.

Office for National Statistics, 2015. Internet Access - Households and Individuals. *Statistical Bulletin*. Available at: http://www.ons.gov.uk/ons/rel/rdit2/internet-access---households-and-individuals/2015/index.html [Accessed October 22, 2015].

Sandborn, P., 2013. Design for obsolescence risk management. *Procedia CIRP*, 00, pp.15–22. Available at: http://www.sciencedirect.com/science/article/pii/S2212827113005477 [Accessed January 30, 2014].

SIEMENS, 2014. Internet of Things: Facts and Forecasts. *Pictures of the Future*. Available at: http://www.siemens.com/innovation/en/home/pictures-of-the-future/digitalization-and-software/internet-of-things-facts-and-forecasts.html [Accessed November 20, 2015].

Solomon, R., Sandborn, P. & Pecht, M., 2000. Electronic part life cycle concepts and obsolescence forecasting. *… , IEEE Transactions on*, 23(4), pp.707–717. Available at: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=888857 [Accessed January 13, 2014].

Thomsen, A., van der Flier, K. & Nieboer, N., 2015. Analysing Obsolescence, an elaborated model for residential buildings. *Structural Survey*, 33(3), pp.210 – 227.

Williams, R. & Edge, D., 1996. The social shaping of technology. *Research Policy*, 25(6), pp.865–899.

World Economic Forum, 2015. *Deep Shift Technology Tipping Points and Societal Impact*, Geneva, Switzerland. Available at: http://www3.weforum.org/docs/WEF_GAC15_Technological_Tipping_Points_report_2015.pdf.