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IDENTIFYING AND MANAGING ASSET OBSOLESCENCE WITHIN THE BUILT ENVIRONMENT

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ABSTRACT

Obsolescence in practice commonly occurs in two forms; the asset in question is no longer suitable for current demands, or is no longer available from manufacturers. Most research surrounding obsolescence has targeted short lifecycle components such as electronics or software (2-5 years). There is little consideration of low volume, long-life assets (20+ years) that are commonplace within the built environment (e.g. Uninterruptable Power Supply Systems, Building Management Systems and Fire Alarm Systems). This paper evidences the importance of identifying asset obsolescence within the built environment by observing ‘lifecycle mismatches’ within a live case study of a ten year old UK Private Finance Initiative (PFI). This paper develops and proposes an original assessment tool, identifying obsolescence within the built environment and empirically tests it within the case study. The methodology and results combine to evidence the importance of obsolescence and the contractual and financial risk it poses. The model is transferrable and scalable thus allowing larger portfolios to be considered. The levels of identifying obsolescence within long-life assets are increasing, whilst the lifecycles of certain component groups are decreasing; posing a growing problem for future Facility Managers.

Keywords: obsolescence, asset management, risk, planning, PFI

INTRODUCTION

Obsolescence within the built environment is normally considered as a broad construct related to the physical structure, location or economics that changed over decades (Cowan et al. 1970; Lemer 1996). The inclusion of computer hardware and software within built environment systems (i.e. fire emergency systems, security systems and building management systems to name three prominent ones) has fundamentally changed this view of obsolescence within the built environment sector. In addition, this type of obsolescence, well known in aerospace and defense, is poorly understood within the Built Environment sector (Singh, P. Sandborn, et al. 2004; Sandborn & Singh 2002; Solomon et al. 2000). This is especially the case for operations, i.e. facility management, where there is increasingly a high risk of systems failure due to technological obsolescence within the operating systems of a building. These failures lead to unforeseen and unplanned operational expenditure. This paper seeks to explore this new type of obsolescence within the context of a Private Finance Initiative (PFI) case study in order to develop and validate an obsolescence assessment tool.

The case study featured in this paper uncovers ‘obsolescence driven investments’ in the region of hundreds of thousands of pounds annually (Bradley & Guerrero 2008). Obsolescence occurs when an asset and/or component is no longer suitable for current demands or is no longer available from manufacturers (CMCA UK 2013; BSI 2007; Bartels et al. 2012; Singh, Peter Sandborn, et al. 2004). Such an event impacts upon the ability to maintain or repair the asset, therefore the resilience of the system (McDaniels et al. 2008). Obsolescence is magnified when ‘lifecycle mismatches’ are present, typically when a long life asset contains short life components such as electronics and/or software, which are required to sustain operational status (Bradley & Guerrero 2008). Therefore, a means of modeling this relationship would enable a more proactive management approach. This paper proposes such a model in order that the obsolescence risks can be identified and mitigated.

CONTEXT

This paper is set out in the context of a 30-year PFI redevelopment contract for a large office block in central London (referred to as *Building A*). The UK government began using PFI’s in 1992 to deliver and manage large infrastructure project. It was reported that in 2012 the UK had over 700 live PFI’s, which equated to £301.32bn (capital and unitary payments) (The Guardian 2012). The payment mechanisms within these contracts contain strict compliance guidelines, which if fouled result in large payment deductions to the PFI contractor. Therefore the resilience of critical asset systems within PFI infrastructure are particularly appropriate given the need to mitigate the immediate risks from deductions for non-availability and expensive short-term borrowing costs for unplanned capital expenditure.

The case study long-term contract contains a large asset register that was experiencing rising lifecycle costs, some of which were ‘obsolescence driven investments’. These occur when either obsolescence or lifecycle mismatches arise unforeseen by management, leading to a reactive response which typically involves the purchasing of upgrades or spares packages – a very capital intensive solution with implications on borrowing costs and ongoing management (Sandborn & Singh 2002). *Building A* experienced the following unforeseen obsolescence driven investments over a short time period:

• Building Management System	≈ £ 370,000.00	(since 2009, 75% of LC CapEx)
• Security Systems	≈ £ 250,000.00	(since 2009, 40% of LC CapEx)
• Fire Alarm Systems	≈ £ 40,000.00	(since 2007, 99% of LC CapEx)
Total	≈ £ 664,000.00	

A percentage of the total lifecycle capital expenditure (LC CapEx) of these systems is shown to illustrate the comparative size and impact that obsolescence had on these systems. The onsite Asset Manager along with other senior management were aware of these investments, however did not have the time or tools to identify these trends and therefore mitigate future investments of this type.

A case study methodology was chosen to frame this research because it was felt that to explore the real life applicability of a decision-aiding tool, a real life scenario of unknown events was required. A case study allows for the collection of 1st hand data from UK suppliers and distributors whilst directly communicating with the lifecycle fund managers to extract their thoughts and opinions surrounding obsolescence. The potential disadvantage of taking a conceptual model and testing it within a case study is that there are no guarantees that the data being inputted will show a distinctive result, which is the common weakness of using low volume data of slow moving asset systems. As with any methodology, there are strengths and weaknesses and in order to quality assure the data being collected, all information was cross checked with onsite information management systems (IMS) e.g. asset registers and O&M materials.

To support the case study a comprehensive literature review was undertaken to compile existing research and to develop an appropriate research design. From reviewing current literature, it is clear that obsolescence research evolved from a purely inventory management consideration of linear deterioration of assets, exemplified by the works by Feldstein & Rothschild (1974) and Warmington (1974) in the 1970's. To more analytical methods for optimum spare parts and replacement strategies that emerged with the use of stochastic and Monte Carlo techniques in works such as Kumamoto & Henley (1980), Waddell (1983), Williams (1984) and Fishman (1987). In the 1990's the research literature began to consider the lifecycle of assets and therefore consider a more holistic view, which would naturally considers the conundrum of what to do with assets when they become obsolete. The work by Abdel-Malek & Wolf (1994), Choi (1994) and Graedel (1996) all move towards the use of lifecycle assessment models and weighted matrices, simultaneously there was an emergence of literature considering the 'final order' problem which comprehensively combines both of the aforementioned research trends (Teunter & Haneveld 1998). On the turn of the new millennium there was a distinct transition of research attention towards the forecasting of the obsolescence phase of a lifecycle with the ambition of promoting proactive strategies. Exemplary pieces of literature include the British Standard published document PD6667:2000 (2000), Sandborn (2004) and Singh & Sandborn (2005) who view obsolescence in contrasting ways. The plethora of publications by both Sandborn and Singh use large data sets that is typically available to manufacturers, allowing for insightful data analysis. The main findings from the empirical literature point to the need for analysis of component level information over time in terms of end of life and product discontinuation to establish risk profiles within a system.

MAIN DISCUSSION

At any given moment in time, a manufacturer can cease production of a part, asset or line of products which equate to the release of an end of life (EOL) or product discontinuance notice (PDN) (BSI 2007). This results in the initiation of the 'Obsolescence Phase' of the lifecycle (shown in Figure 1), once the last order date has been exceeded the product becomes obsolete (Solomon et al. 2000). Obsolescence is unavoidable; however, the additional spiralling costs are not (Solomon et al. 2000; Romero Rojo et al. 2010).

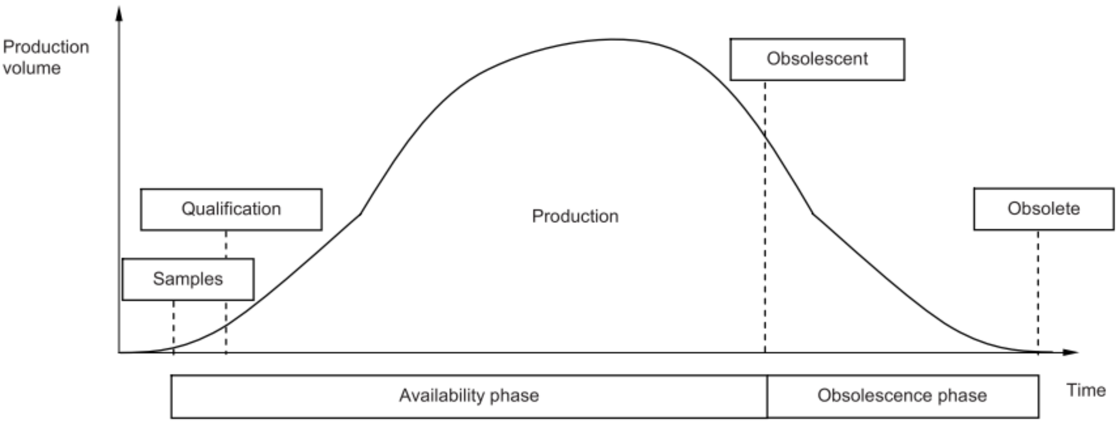

Figure 1 Asset Lifecycle and the introduction of an 'Obsolescence Phase' (BSI 2007)

The obsolescence assessment tool (OAT) developed under this research was built upon a formula originally published by Bartels et al. (2012), used to generate a reflective index against an assets component register. The formula was extended to consider the possibility of using a third party or secondary market as a mitigation method along with a weighting mechanism to highlight both valuable and critical assets. OAT's output is an assets health score which is then measured against the suggested threshold levels suggested by Bartels et al. (2012); shown in Figure 2.

Figure 2 Asset Health threshold levels, adapted from Bartels et al. (2012)

The development stage of OAT had identified a potential issue in the validation of the threshold levels recommended; as such a methodology had not previously been tested and published. Therefore, a case study was required to empirically test the application and also the validity of such a methodology for identifying current levels of obsolete parts. To further enhance the use of OAT an added functionality of weighted inputs for more critical and valuable assets was inserted. This allows for a more contextualized output from OAT that is site specific. The sample asset systems selected for this case study were the Building Management System (BMS), Security System and Fire Alarm System due to their criticality to the function of an office building and high levels of technology. OAT uses a Boolean decision tree to assess and assign component parts with 'statuses' that allow for the categorisation of an asset by situational factors; such as alternative suppliers, EOL notices and alternative parts. It is this functionality of OAT along with the weighting of value and criticality that allow for the visualisation of obsolescence levels. Due to the constraint of time that existed on this project and the nature of slow moving, low volume assets there was not enough data to witness how these levels moved over time. It would therefore be possible to explore the correlation, if any between rising levels of obsolescence and the lifecycle investments made into an asset system.

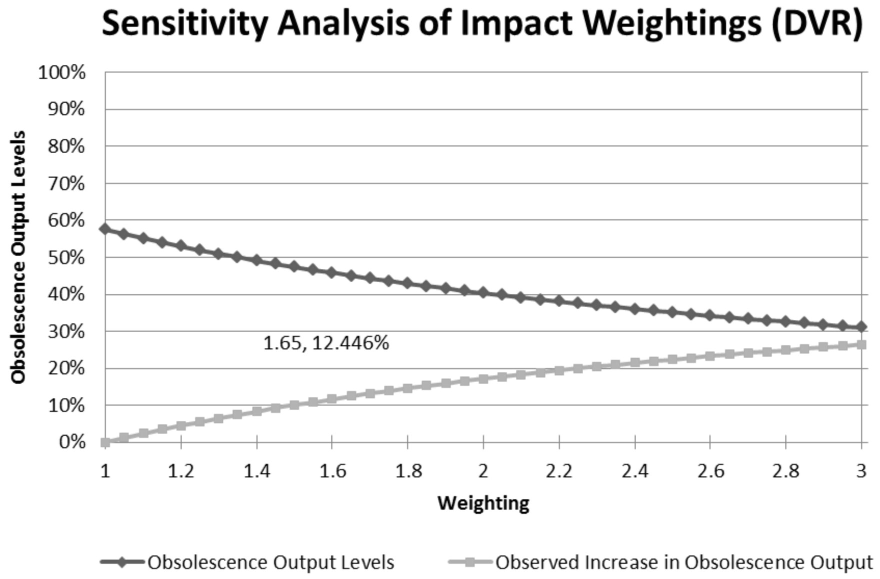

Figure 3 Sensitivity analysis of impact weightings on Security System Assets

BCIS Code 5 - Service asset systems typically contain higher levels of technology and electronic components, which from the literature review had proved to be a higher risk category, hence their selection for the case study (Feng et al. 2007). Segmentation of the asset register by lifecycle cost and an internal survey for criticality of asset system were used to create the groups to be assigned weighting within the model. The narrative being, if two assets contained high levels of obsolete parts, then the assets value and/or criticality should be considered when prioritising resources.

To validate the allocation of weightings across the zones, a sensitivity analysis was undertaken; this involved running the asset health score outputs (un-weighted and in isolation) for each asset and incrementally increase the weighting. The aim was to achieve a maximum influence on the asset health score to move half of a threshold level (12.5% - see Figure 2). Figure 4 illustrates how the suggested maximum weightings from either plugin should be in the region of 1.6 and 1.7 with the in between zones to be divided equally. The resultant suggested weighting for each zone were, Zone 1 – 1.0, Zone 2 – 1.23, Zone 3 – 1.46 and Zone 4 – 1.70. Finally, all three assets were analysed through OAT using the two additional plugins to influence their outputted asset health values, the Building Management System results are shown in table 1 as an example.

Table 1 OAT results from the Building Management System

Two or more suppliers (S) =	8987
One supplier and no EOL notice (Y1) =	4098
One supplier and EOL notice (Y2) =	0
Obsolete part and no solution (O) =	1352
Unknown Status (U) =	0
Alternative part and no EOL notice (A1) =	0
Alternative part with EOL notice (A2) =	4721
Total =	19158 component parts
Asset Health Score =	68.300%
Therefore,	Medium Levels

The case study Building Management System consisted of a high quantity of components of which, over 1000 were deemed obsolete with no alternative supplier or like for like alternative. OAT allows the user to explore what components explicitly fall into that category allowing for immediate mitigation measures to be implemented, an example is shown in Figure 4. The resultant scenario could be, the onsite FM team contact the supplier directly to discuss the availability of the aforementioned parts whilst exploring the compatibility of the new product (if there is one), as these conditions will heavily impact on the possible mitigation strategy. Results similar to the above case are then visualised by OAT, as shown in Figure 5. The bar charts represent the model in three isolated iterations with an average of the three also represented, allowing the FM team to assess an asset's criticality and value to judge whether the weightings are appropriate and the resultant mitigation strategy.

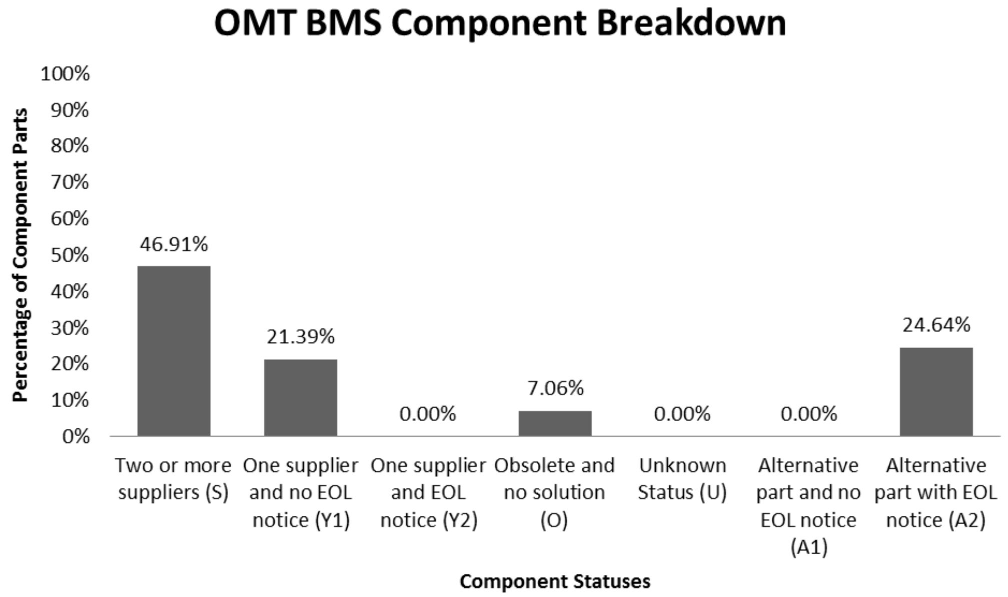

Figure 4 OAT Building Management System component breakdown

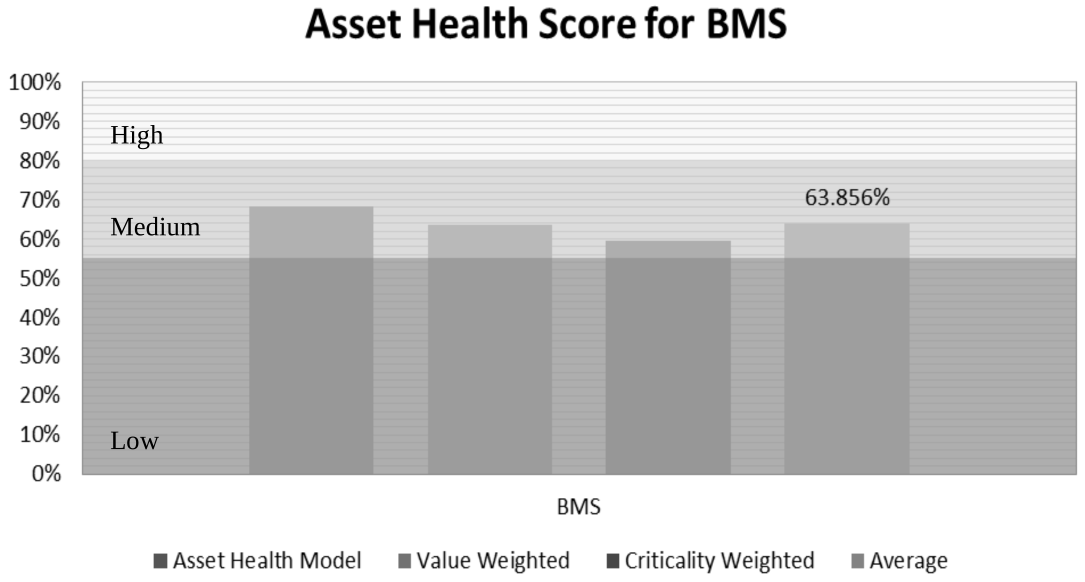

Figure 5 Asset Health score for Building Management System asset

SUMMARY & CONCLUSION

To summarise the findings of this research project the *Building A* case study has highlighted the extent to which obsolescence can cause unforeseen lifecycle investments; these are exacerbated by the sudden manner in which they are uncovered. Meanwhile the case study has also shown how the reality of only certain elements of a system going obsolete can potentially go unknown if the appropriate level of information is both not collected and monitored. The lack of clarity towards the correct methodology to identify and monitor obsolescence has been coupled with gaps within the current research field identified earlier in this report. OAT has the potential to inform FM teams of systems across a portfolio that contain high levels of obsolete parts which could equate to unforeseen obsolescence driven investments in the forthcoming future. The consequence of obsolescence within a system is not covered within this research project and therefore it remains unknown if the actual risk profile created by ‘medium levels’ of obsolescence is a high risk for example. The applicability and use of OAT within industry has shown some merit, granted continued testing within contrasting case studies is required to add confidence to its benefits. However, the conceptual benefits of proactively mitigating obsolescence following a notification via OAT can be in the region of hundreds of thousands of pounds annually for a single contractor. OAT provides the level of information required to begin drafting a mitigation strategy in order to continue the support of a system for a foreseeable period. For example, the results shown in Figure 4 could be used to decide that parts under the status ‘A2’ (24.64%) could be mitigated using spare parts procurement whilst the ‘O’ (7.06%) status components may require a design review. The advantage being that the FM team are proactively seeking this information and making decisions on a strategic level to ensure that when components become obsolete it is known and actually planned.

RECOMMENDATIONS

It is recommended that continued research into this field to aid FMs both inside and outside the PFI industry to improve their budgetary planning within lifecycle model whilst reducing the operational risk due to obsolescence. In addition it is recommended that OAT undergoes further case study testing to validate its scalability and transferability with larger data sets from diverse portfolios. This will identify if systems from other industry sectors behave differently, for example specialist medical equipment in large-scale hospitals. Similarly, there is scope to extend OAT from an assessment tool, to a financial risk tool to aid FMs and their asset registers, both of which will be covered by this author.

REFERENCES

Abdel-Malek, L. & Wolf, C., 1994. Measuring the impact of lifecycle costs, technological obsolescence, and flexibility in the selection of FMS design. *Journal of Manufacturing Systems*, 13(1), pp.37–47. Available at: http://www.sciencedirect.com/science/article/pii/0278612594900167 [Accessed February 11, 2014].

Bartels, B. et al., 2012. *Strategies to the Prediction, Mitigation, and Management of Product Obsolescence* 1st ed., New Jersey: John Wiley & Sons Inc.

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, 2000. *Obsolescence Management - Code of practice for obsolescence notification and support from suppliers of electronic components*, London PD 6667.

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

Choi, J., 1994. Network externality, compatibility choice, and planned obsolescence. *The Journal of Industrial Economics*, 42(2), pp.167–182. Available at: http://www.jstor.org/stable/10.2307/2950488 [Accessed January 21, 2014].

CMCA UK, 2013. What is Obsolescence Management? Available at: http://www.cmcauk.co.uk/what-is-obsolescence-management/ [Accessed January 4, 2014].

Cowan, P. et al., 1970. *Obsolescence in the Built Environment*, London.

Feldstein, M. & Rothschild, M., 1974. Towards an Economic Theory of Replacement Investment. *Econometrica: Journal of the Econometric …*, 42(3), pp.393–424. Available at: http://www.jstor.org/stable/10.2307/1911781 [Accessed January 22, 2014].

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].

Fishman, G.S., 1987. A monte carlo sampling plan for estimating reliability parameters and related functions. *Networks*, 17(2), pp.169–186. Available at: http://doi.wiley.com/10.1002/net.3230170204.

Graedel, T.E., 1996. Weighted matrices as product life cycle assessment tools. *The International Journal of Life Cycle Assessment*, 1(1), pp.85–89.

Kumamoto, H. & Henley, E.J., 1980. Dagger-Sampling Monte Carlo For System Unavailability Evaluation. *IEEE Transactions on Reliability*, 29(2), pp.122–125.

Lemer, A., 1996. Infrastructure obsolescence and design service life. *Journal of Infrastructure Systems*, (December), pp.153–161. Available at: http://ascelibrary.org/doi/abs/10.1061/(ASCE)1076-0342(1996)2:4(153) [Accessed February 3, 2014].

McDaniels, T. et al., 2008. Fostering resilience to extreme events within infrastructure systems: Characterizing decision contexts for mitigation and adaptation. *Global Environmental Change*, 18(2), pp.310–318.

Romero Rojo, F.J., Roy, R. & Shehab, E., 2010. Obsolescence management for long-life contracts: state of the art and future trends. *The International Journal of Advanced Manufacturing Technology*, 49(9-12), pp.1235–1250. Available at: http://link.springer.com/10.1007/s00170-009-2471-3 [Accessed January 3, 2014].

Sandborn, P., 2004. Beyond reactive thinking–We should be developing pro-active approaches to obsolescence management too! *DMSMS Center of Excellence Newsletter*, 2(4). Available at: http://enme.umd.edu/ESCML/Papers/ProactiveObsolescenceManagement.pdf [Accessed January 4, 2014].

Sandborn, P. & Singh, P., 2002. Electronic part obsolescence driven product redesign optimization. *Proceedings of the 6th Joint FAA/DoD/NASA …*, pp.1–13. Available at: http://www.enme.umd.edu/ESCML/Papers/AgingAircraft.pdf [Accessed January 29, 2014].

Singh, P., Sandborn, P., et al., 2004. Electronic Part Obsolescence Driven Product Redesign Planning. *International Journal of …*, 7(2). Available at: http://www.enme.umd.edu/ESCML/Papers/MOCA_paper.pdf [Accessed January 30, 2014].

Singh, P. & Sandborn, P., 2005. Forecasting technology insertion concurrent with design refresh planning for COTS-based electronic systems. *Annual Reliability and Maintainability Symposium, 2005. Proceedings.*, pp.349–354. Available at: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=1408387.

Singh, P., Sandborn, P. & Singh, P., 2004. Forecasting Technology Insertion Concurrent with Design Refresh Planning for COTS-Based Electronics Systems. *Logistics Spectrum*, pp.349–354. Available at: http://www.enme.umd.edu/ESCML/Papers/solemocapaper.pdf [Accessed February 11, 2014].

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].

Teunter, R.H. & Haneveld, W.K.K., 1998. The “final order” problem. *1European Journal of Operational Research*, 107, pp.35–44.

The Guardian, 2012. PFI will ultimately cost £300bn. Available at: http://www.theguardian.com/politics/2012/jul/05/pfi-cost-300bn.

Waddell, R., 1983. A model for equipment replacement decisions and policies. *Interfaces*, 13(4), pp.1–7. Available at: http://pubsonline.informs.org/doi/abs/10.1287/inte.13.4.1 [Accessed November 24, 2014].

Warmington, A., 1974. Obsolescence as an Organizational Phenomenon. *Journal of Management Studies*, 11, pp.1–119.

Williams, T.M., 1984. Stock Control with Sporadic and Slow-Moving Demand. *The Journal of Operational Research Society*, 35(10), pp.939 – 948.