Proceedings of the 2007 Industrial Engineering Research Conference
G. Bayraksan, W. Lin, Y. Son, and R. Wysk, eds.

Designing for Technology Obsolescence Management

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Abstract

Many types of products that have to be manufactured and supported for long periods of time lack control over critical parts of their supply chain, e.g., avionics, telecom infrastructure, and industrial controls. As a result, the components and technologies that these products depend on become obsolete long before the product's field life (and sometimes even manufacturing life) ends. Obsolescence management, which is an inevitability for these products, should be considered during product design and when planning for life cycle sustainment. This paper addresses forecasting obsolescence and other strategic planning methods to minimize future obsolescence impact.

Keywords
Obsolescence, DMSMS, Sustainment-Dominated Systems

1. Introduction

"Sustainment-dominated" systems have long-term sustainment costs that significantly exceed their original procurement costs. Sustainment in this context means keeping an existing system operational and maintaining the ability to manufacture and field versions of the system that satisfy the original requirements. A significant problem facing many sustainment-dominated systems is technology obsolescence. No technology typifies the problem more than electronic part obsolescence, where electronic parts refers to integrated circuits and discrete passive components. Driven by the consumer electronics product sector, newer and better electronic parts are being introduced frequently, rendering older parts obsolete - QTEC estimates that approximately 3% of the global pool of electronic parts goes obsolete every month, [1]. As a result, the procurement life span for electronic parts has been shrinking, e.g., Figure 1. Yet, sustainment-dominated systems such as aircraft avionics are often produced for many years and maintained for decades. In particular, sustainment-dominated products suffer the consequences of

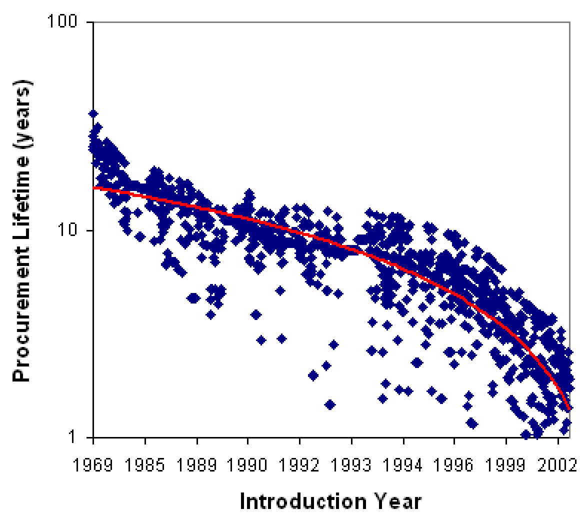

Figure 1: Decreasing procurement lifetime for operational amplifiers, an electronic part common to nearly every electronics application, [2] (the procurement life is the number of years the part can be procured from its original manufacturer)

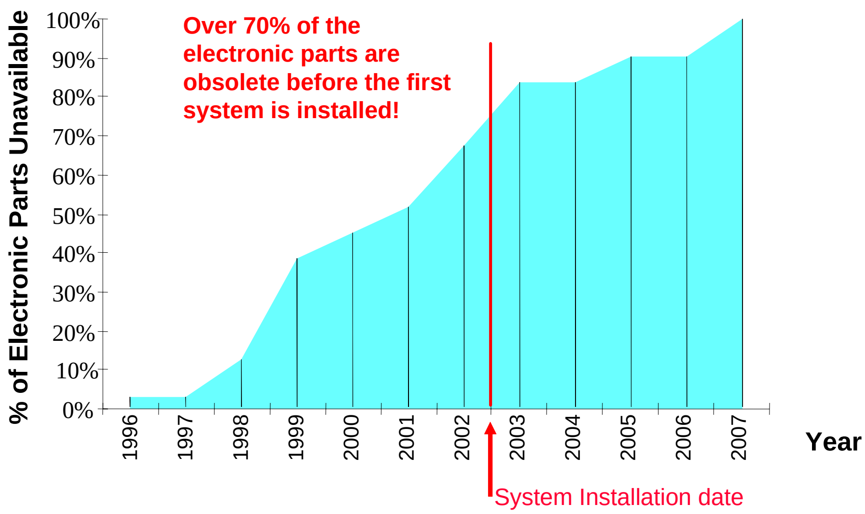

Figure 2: Percent of Commercial Off The Shelf (COTS) parts that are out of production (un-procurable) versus the first 10 years of a surface ship sonar system's life cycle (courtesy of NAVSURFWARCENDIV Crane)

electronic part obsolescence because they have no control over their electronic part supply chain due to their low production volumes. The obsolescence problem for sustainment-dominated systems is particularly troublesome since they are also often subject to significant qualification/certification requirements that can make even simple changes to a system prohibitively expensive. This problem is especially prevalent in avionics and military systems, where systems often encounter obsolescence problems before they are fielded and always during their support life, e.g., Figure 2.

Obsolescence, also called DMSMS – Diminishing Manufacturing Sources and Material Shortages, is defined as the loss or impending loss of original manufacturers of items or suppliers of items or raw materials. The key defining characteristic of "involuntary" obsolescence problems is that the products are forced to change by circumstances that are beyond their control (even though the manufacturers and customers do not want to make changes). The type of obsolescence addressed in this paper is caused by the unavailability of technologies (parts) that are needed to manufacture or sustain a product. A different type of obsolescence (not addressed herein) called "sudden obsolescence" or "inventory obsolescence" refers to the opposite problem in which inventories of parts become obsolete because the system they were being saved for changes such that the inventories are no longer required.

For sustainment-dominated systems, the OEM is being increasingly forced to manage both the manufacturing and the long-term sustainment of the product by advanced logistics concepts such as Performance Based Logistics (PBL) being imposed on them by their customers. Although PBL implies many things, at its core it is essentially a shift from purchasing systems and then separately purchasing their support, to purchasing the availability of systems; simply put, performance-based strategies buy outcomes, not products and force the OEM to minimize the entire life cycle cost of a system.

In most complex systems, software life cycle costs contribute as much or more to the total life cycle cost as the hardware, and the hardware and software obsolescence problems must be considered concurrently, [3]. While hardware obsolescence is generally caused by the end of procurement availability of an item, software obsolescence is usually due to either changes to the hardware (possibly to mitigate a hardware obsolescence problem) or the end of support for the software (sometimes the end of support is accompanied by the termination of licenses to use the software).

2. Managing the Problem – Designing for Involuntary Obsolescence

For systems that are sensitive to technology obsolescence, avoiding obsolescence is generally regarded as nothing more than putting off the inevitable. Designing an electronics rich system that can be supported for 20+ years so that none of it's constitute parts will become obsolete is not considered a practical endeavor. Therefore, design for involuntary obsolescence becomes an exercise in making the problem manageable (or minimizing the life cycle cost of sustaining the system). Figure 3 shows a summary of the hierarchy of "design for" activities that can be undertaken to make involuntary obsolescence manageable.

In order to be manageable, the problem has to first be predictable. Predictability can happen at several levels, first, one may simply have relative knowledge that one part (by virtue of its function) is likely to have a procurement life cycle that is shorter than another part. Most electronic part obsolescence forecasting is based on the development of models for the part's life cycle. Traditional methods of life cycle forecasting utilized in commercially available tools and services are ordinal scale based approaches, in which the life cycle stage of the part is determined from an array of technological attributes, e.g., [5,6] and available in commercial tools such as TACTRAC™, Total Parts Plus™, and Q-Star™. More general models based on technology trends have also appeared including a methodology based on forecasting part sales curves [7], leading-indicator approaches [8], and data mining [9]. Obsolescence forecasting is an "outside looking in" form of product deletion modeling, performed without access to internal business knowledge of the manufacturer of the part. At least one effort has gone further consolidating demand and inventory, and combining it with obsolescence risk forecasting in order to assess application-specific obsolescence prediction, [10]. A few efforts have also begun to appear that address non-electronic part obsolescence forecasting including [11,12].

Most organizations use obsolescence forecasting to audit their Bill Of Materials (BOM) in order to avoid selecting parts that are close to obsolescence, however, when parts become obsolete various mitigation approaches can be employed, [13]. Replacement of parts with non-obsolete substitute or alternative parts can be done as long as the burden of system re-qualification is not unreasonable. Another common approach is lifetime buys of parts, i.e., buying and storing a sufficient number of parts to last through a system's remaining manufacturing and sustainment life when the part goes obsolete, [14]. There are also a plethora of aftermarket electronic part sources ranging from original manufacturer authorized aftermarket sources that fill part needs with a mixture of stored devices (manufactured by the original manufacturer) and new fabrication in original manufacturer qualified facilities (e.g., Rochester Electronics and Lansdale Semiconductor) to brokers and even eBay. David Sarnoff Laboratories operates GEM and AME, [15], which are electronic part emulation foundries that fabricate obsolete parts that meet original part qualification standards using newer technologies (e.g., BiCMOS gate arrays). Thermal uprating of commercial parts to meet the extended temperature range requirements of an obsolete Mil-Spec part is also a possible obsolescence mitigation approach for some parts, [16].

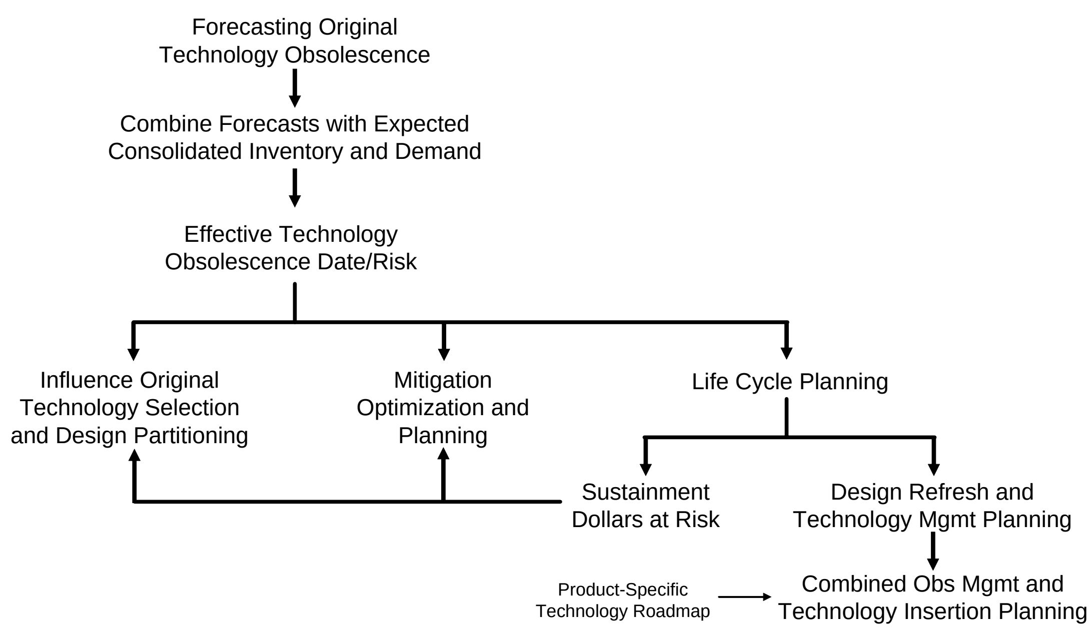

Figure 3: Hierarchy of design for involuntary obsolescence activities. A complete taxonomy of activities associated with electronic part management is available in [4]

Once forecasting is available at some level, other "design for" activities become possibilities. One can consider partitioning the design (dividing hardware into discrete physical partitions), however, often performance constraints override obsolescence management concerns during the design process making partitioning solutions impractical.

If information regarding the expected procurement lifetimes of parts (with appropriate uncertainties quantified) is available during a system's design phase, then strategic approaches that enable the estimation of lifetime sustainment costs are possible, and even with data that is incomplete and/or uncertain, the opportunity for sustainment cost avoidance is potentially significant with the application of the appropriate decision making methods.

Two types of strategic planning approaches have been used to manage technology obsolescence: material risk indices and design refresh planning. Material Risk Index (MRI) approaches analyze a product's Bill Of Materials and scores a supplier-specific part within the context of the enterprise using the part, e.g., [17]. MRIs are used to combine the risk prediction from obsolescence forecasting with organization-specific usage and supply chain knowledge in order to estimate the magnitude of sustainment dollars put at risk within a customer's organization by the selection of the part and the part's eventual obsolescence.

Because of the long manufacturing and field lives associated with sustainment-dominated systems, they are usually refreshed or redesigned one or more times during their lives to update functionality and manage obsolescence. Technology "refresh" refers to system changes that "Have To Be Done" in order for the system functionality to remain useable. Redesign or technology insertion is a term used to identity the "Want To Be Done" system changes, which include both the new technologies to accommodate system functional growth and new technologies to replace and improve the existing functionality of the system, [18]. Unlike high-volume commercial products in which redesign is driven by improvements in manufacturing, equipment or technology; for sustainment-dominated systems, design refresh is often driven by technology obsolescence that would otherwise render the product un-producible and/or un-sustainable. The goal of design refresh planning is to determine when to design refresh (dates) and what obsolete system parts should be replaced at a specific design refresh (versus managing with some other obsolescence mitigation strategy).

The simplest model for performing life cycle planning associated with technology obsolescence (explicitly electronic part obsolescence) was developed by Porter [19]. Porter's approach focuses on calculating the Net Present Value (NPV) of last-time buys and design refreshes as a function of future date. A last-time buy (or bridge buy) means purchasing and storing enough parts when obsolescence occurs to last until a scheduled future refresh date. As a design refresh is delayed, its NPV decreases and the quantity (and thereby cost) of parts that must be purchased in the last time buy required to sustain the system until the design refresh takes place increases. Alternatively, if design refresh is scheduled relatively early, then last-time buy cost is lower, but the NPV of the design refresh is higher. The Porter model performs its tradeoff of last-time buy costs and design refresh costs on a part-by-part basis. In order to treat multiple refreshes in a product's lifetime, Porter's analysis can be reapplied after a design refresh to predict the next design refresh, effectively optimizing each individual design refresh, but the coupled effects of multiple design refreshes (coupling of decisions about multiple parts <u>and</u> coupling of multiple refreshes) in the lifetime of a product are not accounted for.

A more complete optimization approach to refresh planning called Mitigation of Obsolescence Cost Analysis (MOCA) has been developed that concurrently optimizes multiple refreshes and multiple obsolescence mitigation approaches (the Porter model only considers last-time buys), [20]. Using a detailed cost analysis model, the MOCA methodology determines the optimum design refresh plan during the field-support-life of the product. The design refresh plan consists of the number of design refresh activities, their content and respective calendar dates that minimize the life cycle sustainment cost of the product.

While many sustainment-dominated products seek design refresh solutions, design refreshing solely to manage obsolescence is not practical for every system. For many systems, technology insertion roadmaps are developed to dictate how the system's functionality and performance must be changed over time. Technology roadmaps reflect an organization's internal technology goals and budget cycles, and may be dictated by the customer. The MOCA methodology has been extended to include technology roadmapping constraints, [21,22]. The integration of technology roadmap information into MOCA's decision analysis ensures that selected refresh plans meet roadmap imposed timing and budget constraints, and that the costs of roadmap specified actions are included in relevant refreshes.

3. Conclusions

System sustainment problems are going to get worse, not better in the future and either already are or are going to become significant life cycle cost drivers in numerous product sectors that, by definition, do not control critical portions of their technology supply chain and never will control them. The key for many of these product sectors will be learning to design for the inevitability of technology obsolescence. Although present driving applications are those that involve electronic parts, solutions could contribute to fundamental technology insertion decision making for long-life sustainment-dominated systems in general, as well as shorter-life high-technology products such as computer hardware and software.

There are several real payoffs from strategic management of involuntary obsolescence problems. Such activities have the potential to provide product managers with the ability to predict as early as possible how to best design and plan for system sustainment:

- more accurate allocation of budget earlier in product development phases
- more accurate guidelines for how systems are modified at design refreshes
- improved operational availability
- enables broader impacts to be considered when mitigation approach decisions are made
- enables the opportunity for shared solutions across multiple systems and applications.

References

1. QTEC, 2006, http://www.qtec.us/Products/QStar_Introduction.htm.
2. Feldman, K., and Sandborn, P., 2007, "Integrating Technology Obsolescence Considerations into Product Design Planning," to be published Proceedings of the ASME Design for Manufacturing and Life Cycle Conference, Las Vegas, NV.
3. Sandborn, P., and Plunkett, G., 2006, "The Other Half of the DMSMS Problem - Software Obsolescence," DMSMS Knowledge Sharing Portal Newsletter, 4(4), 3 and 11.
4. Sandborn, P., Jung, R., Wong, R., and Becker, J., 2007, "A Taxonomy and Evaluation Criteria for DMSMS Tools, Databases and Services," Proceedings of the Aging Aircraft Conference, Palm Springs, CA.
5. Henke, A.L., and Lai, S., 1997, "Automated Parts Obsolescence Prediction," Proceedings of the DMSMS Conference, San Antonio, TX.
6. Josias, C., Terpenny, J.P., and McLean K.J., 2004, "Component Obsolescence Risk Assessment," Proceedings of the Industrial Engineering Research Conference (IERC), Houston, TX.
7. Solomon, R., Sandborn, P., and Pecht, M., 2000, "Electronic Part Life Cycle Concepts and Obsolescence Forecasting," IEEE Trans. on Components and Packaging Technologies, 23(4), 707-713.
8. Meixell, M., and Wu, S.D., 2001, "Scenario Analysis of Demand in a Technology Market Using Leading Indicators," IEEE Transactions on Semiconductor Manufacturing, 14(1), 65-78.
9. Sandborn, P., Mauro, F., and Knox, R., 2007, "A Data Mining Based Approach to Electronic Part Obsolescence Forecasting," IEEE Trans. on Components and Manufacturing Technology (in press).
10. Tilton, J.R., 2006, "Obsolescence Management Information System (OMIS)," http://www.dmsms.org/file.jsp?storename=OMIS_article1.pdf, Navy Underwater Warfare Center, Keyport, WA.
11. Howard, M.A., 2002, "Component Obsolescence – It's Not Just for Electronics Anymore," Proceedings of the Aging Aircraft Conference, San Francisco, CA.
12. ARINC, Inc., 2006, "ARINC Logistics Assessment and Risk Management (ALARM) Tool," http://www.arinc.com/news/2005/06-28-05.html.
13. Stogdill, R.C.., 1999, "Dealing with Obsolete Parts," IEEE Design & Test of Computers, 16(2), 17-25.
14. Feng, D., Singh, P., and Sandborn, P., 2007, "Optimizing Lifetime Buys to Minimize Life cycle Cost," Proceedings of the Aging Aircraft Conference, Palm Springs, CA.
15. Johnson, W., 2000, "Generalized Emulation of Microcircuits," Proceedings of the DMSMS Conference, Jacksonville, FL.
16. Pecht, M., and Humphrey, D., 2006, "Uprating of Electronic Parts to Address Obsolescence," Microelectronics International, 23(2), 32-36.

17. Robbins, R.M., 2003, "Proactive Component Obsolescence Management," A-B Journal, 10, 49-54.
18. Herald, T.E., 2000, "Technology Refreshment Strategy and Plan for Application in Military Systems – A How-To Systems Development Process and Linkage with CAIV," Proceedings of the National Aerospace and Electronics Conference (NAECON), 729-736, Kansas City, MO.
19. Porter, G.Z., 1998, "An Economic Method for Evaluating Electronic Component Obsolescence Solutions," Boeing Company White Paper.
20. Singh, P., and Sandborn, P., 2006, "Obsolescence Driven Design Refresh Planning for Sustainment-Dominated Systems," The Engineering Economist, 51(2), 115-139.
21. Sandborn, P., Herald, T., Houston, J., and Singh, P., 2003, "Optimum Technology Insertion into Systems Based on the Assessment of Viability," IEEE Trans. on Components and Packaging Technologies, 26(4), 734-738.
22. Myers, J., and Sandborn, P., 2007, "Integration of Technology Roadmapping Information and Business Case Development into DMSMS-Driven Design Refresh Planning of the V-22 Advanced Mission Computer," Proceedings of the Aging Aircraft Conference, Palm Springs, CA.