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Technology Management Forecasting and Predictions for System of Interest Analysis

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Abstract

This paper proposes a methodology that proactively and logically addresses the Design Decisions and Obsolescence Planning challenges of a program. A case study is conducted using a large-scale IT network system design and deployment program. The actual performance of the system and change costs are analyzed using the Rapid Response and Technology Trade (R2T2) model developed at Lockheed Martin Maritime Systems & Sensors to trade against other change management alternatives. The case study historical insight then provides the system designer with a methodology for better modeling and planning of future IT-based designs.

The paper first introduces the need for technology and obsolescence modeling in Section 1 and then provides background history and decisions for the selected case study in Section 2. Section 3 documents the case study model inputs, actual system data gathered over an 8-year period and includes tools and assumptions used for this study. Section 4 delineates the output synthesis from the R2T2 model analysis. Finally, Section 5 provides conclusions regarding the output synthesis that explore how other optional change plans provided either performance or cost benefits for the case study. Additionally, Section 5 discusses recommendations relating to IT network projects that are extensible into many system solutions that maximize commercial product content. In order to ensure consistent discussion, Annex A provides definitions for some of the terminology employed within this publication.

Section 1. Introduction

Whether in commercial, military, government or international businesses, the rapid pace of technology change, especially with Information Technology (IT) based systems, necessitates a greater need for an affordable system change management model. This need in turn provides an opportunity to leverage system advantages through program modeling, support planning, skill requirements analysis and performance growth over the system life cycle. Thus, development and delivery of a system solution to the customer is no longer sufficient, and concurrent modeling for the inevitable technology (and product) changes emerges as a task incumbent upon systems engineering. A further challenge for the system architect and designer includes multiple hierarchical layers to the system, each of which requires scrutiny of the technologies, products, standards and processes that make up each system element. Each higher system layer adds more elements of interest, each of which should be modeled, analyzed and aggregated into a system level solution. Therefore, in addition to the traditional system engineering process functions (ISO/IEC, 2002), there are other systems engineering responsibilities that demand earlier attention.

- Design Decisions - Technology and product migration of system elements during the proposal, concept exploration and development phases for optimal value (performance versus affordability and risk) design decisions
- Obsolescence Planning - Modelling of system elements for affordable system change management during all life cycle phases (from proposal and conceptual design through support)
- Technology Road Mapping – Determine the next obsolescence event or functional insertion solution development
- Support System – Provide design recommendation for the support options of the solution

This paper proposes a methodology that proactively and logically addresses the Design Decisions and Obsolescence Planning challenges enumerated above. A case study is conducted using a large-scale IT network system design and deployment program. The actual performance of the system and change costs are analyzed using the Rapid Response and Technology Trade (R2T2) model developed at Lockheed Martin Maritime Systems & Sensors to trade against other change management alternatives. The case study historical insight then provides the system designer with a methodology for better modeling and planning of future IT-based designs.

The support of technologically high-end systems certainly involves obsolescence management within the delivered solution across an extended lifecycle. This paper studies a 14,000 node IT Network System from a Technology Management and Forecasting Prediction perspective that affordably addresses change management of the system commercial volatility.

DoD 5000.2-R (DoD 2001) addresses refreshment as "improving product affordability, system reliability, maintainability and supportability via continuous dedicated investment in technology refreshment . . .", ". . . assuring sustainment and implementing technology insertion, to continually improve product affordability", ". . . the PM shall conduct a business case analysis to justify acceptance of the associated economic impacts on TOC and risks to technology insertion and maturation over the service life of the system" and "System design shall facilitate the later insertion of leading edge, dual-use technologies and components throughout the system life cycle".

In an article for PM Magazine, Linda Haines (Haines 1999) quoted a technology refreshment definition as "the periodic replacement of Commercial Off-The-Shelf (COTS) components; e.g. processors, displays, computer operating systems, and commercially available software (CAS) within larger DoD systems to assure continued supportability of that system through an indefinite service life." (Alford 2003)

These complete definitions cover several common threads directly applicable to any system. Technology Management must consider the evolution of technology, the refreshment of technologies and system products, as well as the insertion and growth of system functionality over time, and all within the framework of affordable support of the system through the life cycle. Achieving objective requirements must occur within a coordinated and planned approach to obsolescence management and simultaneous performance growth. While the need for obsolescence management is necessary for all system elements, it is even more critical for the commercially system elements. The IT network system case study provides estimates on the expected growth in performance capacity, which will facilitate achieving objective requirements (functional growth) in an affordable manner through the system life. Strategically, a program plan is required to manage and leverage technology evolution and eventual product obsolescence. The model outputs include:

- Program Planned Change Period (Determined by the IT Network technologies)
- Product (or sub-system) Deployment and Retirement Plans
- Hardware/Software Change Non-Recurring Design/Test Costing Assessment
- Recurring Support Costing Assessment
- Functional Capacity Delta Assessment

From a support perspective, the plan must manage the changes (which are necessary for both obsolescence and to accommodate customer-driven functional enhancements) against an affordability assessment. Technology insertions (i.e. functional growth) should be synchronized with the planned obsolescence change activity to optimize re-testing and validation costs, and will efficiently maximize the solution viability.

The Rapid Response Technology Trade Study (R2T2) model provides two critical planning insights using the IT Network.

1. How often should the IT Network be changed in the Operation and Support (O&S) phase to optimize on affordability? (i.e. What is the IT Network Strategy for O&S?)
2. What will be the forward Technology Management Plan for each system critical element? (Using the results from the obsolescence analysis.) This output is available upon request.

From these insights, an understanding of how the IT Network would have benefited over the last 8 years of operation, and more importantly offer recommendations for how to proceed during the next 10 or more years.

Section 2. IT Network Case Study Background

In mid-1995, development and implementation began for what is now a 14,000 user, 400-location, global computer network for organizational connectivity and communication of clients and users. The network provides access to vital mainframe data, e-mail and a few custom applications and is built using Cisco routers, 3COM devices, Microsoft Windows 95 and Windows NT. The servers and workstations utilize the Intel platform and Pentium processor technology. Approximately 95% of the system is comprised of unmodified commercial product content. The remaining 5% represents a few custom software applications.

The IT network studied has evolved and been deployed over the last eight years. The design and support services include areas such as network operating systems, local and wide area network communications, desktop operating systems, peripherals and custom application integration. This paper uses the workstations (hardware and software), routers, basic peripherals (i.e. printers), switches and servers (hardware and software) upgrade cycles over 8 years to provide insight into change management options. The historical information provides the foundational data input for analysis in Sections 4 and 5.

1. Servers

The initial server environment was deployed utilizing Microsoft's Windows NT v4.0 and Microsoft Exchange running on dual Intel Pentium 90 MHz microprocessors. The servers are of server-grade quality and deployed throughout the infrastructure. The initial disk capacity was approximately 70GB with little margin for growth. The server deployment experiences similar configuration challenges as do the workstations. However, since the technology evolution of server hardware occurs approximately every 6 to 8 months, and workstation hardware evolution occurs every 5 to 6 months, the servers remain only slightly more stable. Server technology evolutions typically involve faster memory, faster processors or additional hard disk capacity and often at no additional package cost. Thus, when server technology does provide a new capability such as proactive monitoring, external storage or redundancy, that capability is usually implemented, whether or not it is actually needed by the user. There are 282 deployed sites in our IT network and there is roughly one server per site that supports each local area network.

In early 2002, a migration strategy was designed that transitioned the existing Window's platforms to Windows XP, Windows 2000 with Active Directory (AD) and Exchange 2000. In this effort, all server and workstation hardware would be replaced with Windows compliant hardware. It was estimated that the design and engineering would take 18 months to complete and another 18-24 months to globally deploy the solution.

2. Workstations

The initial computer network was designed to enable communication with 20 major LAN hubs throughout the continental United States that represents approximately 70% of the users. The workstation deployment consisted of Pentium 90 workstations and Microsoft Windows 95. Most of the applications available for the end user include mainframe applications, productivity software, e-mail and some business-specific functionality. The majority of software has low complexity and requires only moderate processing, storage and graphical user interface capabilities. As the workstation infrastructure was built, technology moved forward and product obsolescence required that various configurations of workstations be deployed in the enterprise. New workstation configurations are required to ensure backward compatibility as patches and new applications are deployed. Each version typically reflects the latest vendor configuration or bulk purchase of the period. As a result, between the years of 1995 and 2002, approximately 17 different Windows 95 hardware configurations were deployed ranging from the Pentium to Pentium III processors. In other words, there is no planned hardware refreshment per se; if a workstation fails, then it is replaced with the newest compatible configuration.

As of mid-2004, the program has been rapidly deploying servers, workstations and telecommunications equipment globally. The migration challenges faced by the organization have been costly, and on the order of a full redesign cost. This is because as sites are migrated, other sites with old and antiquated equipment experience failures and compatibility issues. Since the equipment is end-of-life and either no longer available or no longer supports Windows 95, a stopgap process was created to handle repairs until the site can be upgraded. If a Windows 95 based workstation fails, the system is sent to a depot to be swapped out with another, repaired or restored Windows 95 system. These restored systems represent reused workstations from sites that have been upgraded. System servers and other devices are handled in a similar manner.

3. Communications Network

The telecommunications infrastructure was designed using 7000 series Cisco routers and low-end 3COM hubs and switches. The wide area network infrastructure utilized T-1, point-to-point circuits while most of the local area networks operated on shared or switched Ethernet running at 10Mb/s. Most of the servers communicated with the local area network via 100Mb FDDI in order to maximize end user throughput. The telecommunications infrastructure was originally based on T-1 point-to-point, dedicated circuits due to contractual obligations with the nation-wide data carriers. In 1998, the customer chose to migrate from the costly dedicated point-to-point circuits, to a partially meshed, frame-relay service with low Committed Information Rates (CIR). With the deployment of frame-relay, Cisco 2500 series routers and special hardware-based frame-relay encryptors were employed. Since most of the applications did not require high-speed access, the burstable frame-relay T-1's did suffice. The original Local Area Network (LAN) design employed a hub and spoke configuration, and therefore very few modifications were necessary since 1998. During that time, only the network-to-server uplinks were upgraded to enhance the server-to-user performance.

Beginning in 2001, a pilot project started that would replace the two-device Wide Area Network (WAN) configuration (i.e.: encryptor and router) with a single device capable of routing and encrypting. In addition, instead of utilizing frame-relay technology, optical-based, high-speed public Internet circuits using Virtual Private Network (VPN) technology between sites were chosen with the belief it would reduce cost, increase capacity and provide a more flexible WAN design.

Section 3. Case Study Model Inputs and Assumptions

The model used for this IT network case study is the Rapid Response Technology Trade Study (R2T2) (Herald 2003) capability developed and patented (Hertz, Herald 2004) by Lockheed Martin Maritime Systems and Sensors in Manassas, VA. The R2T2 model is a system aid for technology forecasting and strategy recommendations, and is especially useful during proposal and early conceptual phases, when there is typically a lack of specific part number definition and program details. At these early system stages, a bill of materials is quite general, but technologies can often be identified and leveraged to provide an early warning to the systems architect of system life cycle affordability impacts caused by system integration decisions.

For our IT network case study, R2T2 performs modeling of the initial system baseline configuration and projects the relative cost of following ten various evolution alternatives. These system alternatives use a scheduled change cadence of every 12 months through every 120 months in annual increments. This analysis will either justify the actions taken by the system stakeholders, or to offer insights into how to better spend the limited budget available over the life cycle of 8 years thus far, with a minimum of 19 additional years of projected support.

1. Baseline IT Network Input Data

In order to prepare an appropriate change strategy using R2T2, we start with the IT Network system baseline. This baseline integrates a multitude of technologies, each having its own unique life cycle and frequency of product revision. There is a typical and natural life cycle associated with a product from its initial announcement through product competition and finally into obsolescence. Figure 1 below shows this "bathtub-shaped" curve. Each system element is assessed to determine its particular life cycle characteristics:

- **Technology Life Cycle –** The useful life of a product from its introduction to the point where it is no longer produced and/or supportable. This variable is measured in months.
- **Current Technology Maturity –** This represents the current position of the product along the Technology Life Cycle measured in months (i.e. the age of the product or technology from its industry introduction, note, this is not the time since procurement of a technology or product for our system).
- **Technology Change Frequency –** The frequency of change within that technology that is common and expected for each IT Network system element. This variable is measured in months between changes. For example, Oracle has a stated business model of announcing new database products within a technology family of every 6 months.

- **Technology Doubling Period** – This represents the time in months to double the available capacity change. For items that move slowly, such as power supply technology, the watts/volume metric might be used and a doubling may take 240 months or more. Thus our program will likely not experience much performance growth in power supply technology.

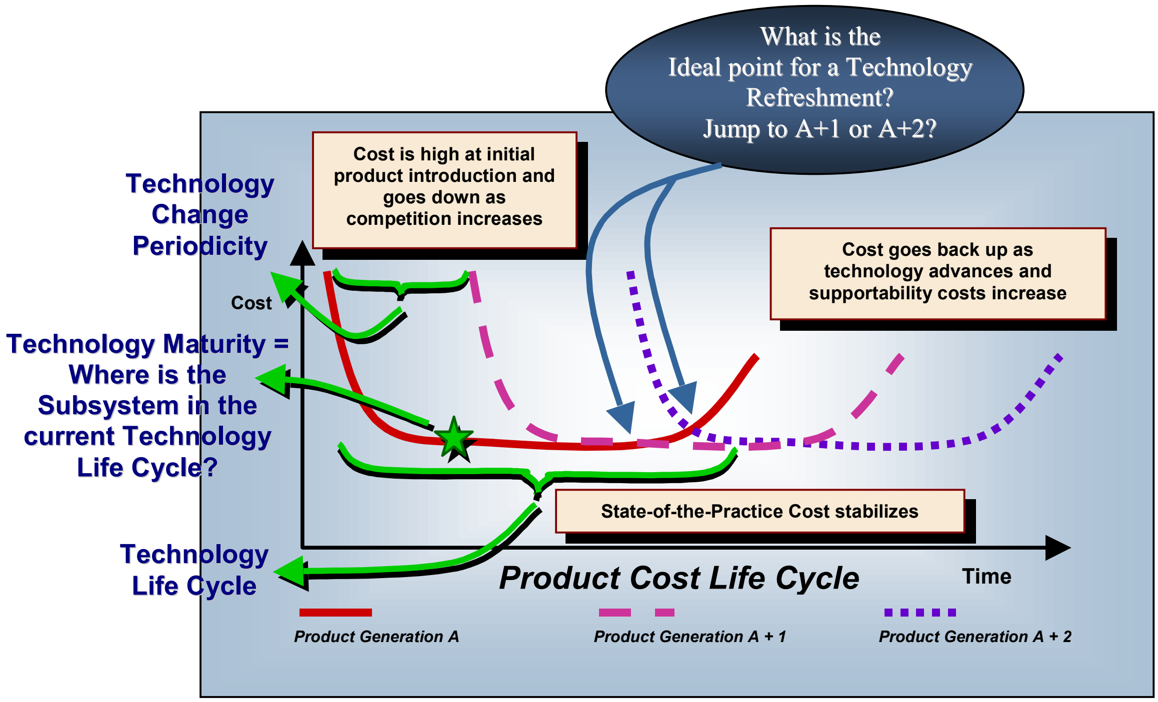

Figure 1. Technology Evolution Metrics enable us to plan Technology Refreshment.

Figure 1 also highlights the challenges with monitoring the chosen technologies and product lines. Once a commercial product has been rigorously selected, predicting when to change to the next product revision, or knowing if to skip a generation before changing is difficult. Factors such as system production schedules, prototype testing interoperability results, software availability and program affordability are all variables to be integrated with the selected product cost life cycle.

The high-level input matrix of the IT network baseline product information necessary for the case study is provided in Table 1 in accordance with the characteristics described above and in Figure 1. This information is augmented by the following list of programmatic inputs necessary to round out the R2T2 data requirements. The Technology Maturity is shown as 12 months for the system elements to account for the time from selection, testing and finally to the beginning of system deployment in 1997 for the state of the art product 1996 product choices.

Table 1. IT Network System Technology. Refreshment Curve and Cost Data

System Element	Technologies / Comments	Tech Life Cycle (Months)	Tech Change Frequency (Months)	Tech Maturity (Months)	Tech Doubling (Months)
Workstation Hardware	Pentium 90 (through Pentium III)	48	6	12	18
Workstation OS	Windows 95	96	36	12	48
Server Hardware	Dual Intel Pentium 90 MHz Microprocessors	48	6	12	18
Server OS	Microsoft's Windows NT v4.0	96	36	12	48
Network Routers	7000 series Cisco routers and low-end 3COM hubs	72	48	12	120
Network Switches	3COM switches	72	48	12	120
Printers	Lexmark high volume and high speed	48	12	12	72

Table 2. IT Network Enterprise Program-level Data for R2T2 Input

Input Data Item	Description	IT Network System Data
Deployment Schedule	Sequencing of system evolution (growth of network nodes for this case study)	1997 = 31 systems deployed, 1998 = 60, 1999 = 62, 2000 = 70, 2001 = 43, 2002 = 13, 2003 = 3 for a total of 282 systems.
Decommissioning Schedule	Planned retirement of the IT Network system	Beginning in 1997, decommissioning follows the deployment schedule and completes in the year 2023
Program Life Cycle	Desired life span of the IT Network from the stakeholders	Assumed to be 20 years from 2003, the last production year
Technology Curve	Includes Technology Life Cycle, Maturity, Change frequency and Technology Capacity doubling	Data shown in Table 1.
Acquisition Cost	For each system element to be analyzed (Quoted or Estimated)	Costs used are 1997 US dollar values. Escalation uses US Government rates.
MTBF	Mean Time Between Failures for each system element (Field Actual or Estimated)	Incorporated for each of the data items in Table 1.
Quantity	The quantity used in the IT Network	Known and ready for input
Optional Inputs	• Sparing Strategy • Repair Strategy • Period Maintenance Plan • IETM (Tech Doc) Level • Part Number.	• Sparing uses MTBF • Remove and Replace Repairs • R2T2 default Maintenance plan • IETM level 3 assumed • Part Numbers available

The Relative Importance of each of the identified system elements is shown in Table 3 based on the acquisition cost value of each system element. Note in the table, that there are other alternatives available for determining system relative importance. The relative importance provides a metric for determining which parts in the system will drive the decision to change. For this IT Network case study, Acquisition Cost was used as the importance parameter. This means that approximately 94% of the change decision is based on the fast changing hardware elements within the network. Indeed this is typically the case that the hardware solution drives the decision to change more so than the purchased software elements including the development applications (not shown in this study).

System Element	RI By Acq. Cost	RI By Computed Price	RI By MTBF
Workstation SW	5.20%	4.38%	2.64%
Server HW	20.77%	21.10%	7.40%
Workstation HW	46.43%	47.16%	0.26%
Server SW	0.98%	0.83%	73.98%
Network Routers	3.64%	3.33%	7.40%
Network Switches	1.13%	1.03%	7.40%
Printers	21.85%	22.19%	0.92%

Table 3. System Element Relative Importance Based on Acquisition Value

Section 4. R2T2 Output Synthesis

The R2T2 model was executed using the inputs and assumptions from Section 3, and using 10 various system alternative change periods in 12 month increments from 12 to 120 months. This model provides a summation of the total ownership cost associated with baseline changes. Figure 2 highlights the normalized cost analysis of the 10 optional alternative solution strategies. The synthesis shows that a model year concept is the most affordable approach for affordably managing this high-tech, fast-changing IT Network. This result is indeed expected since 67 percent of the hardware system is undergoing technology revisions every 6 months.

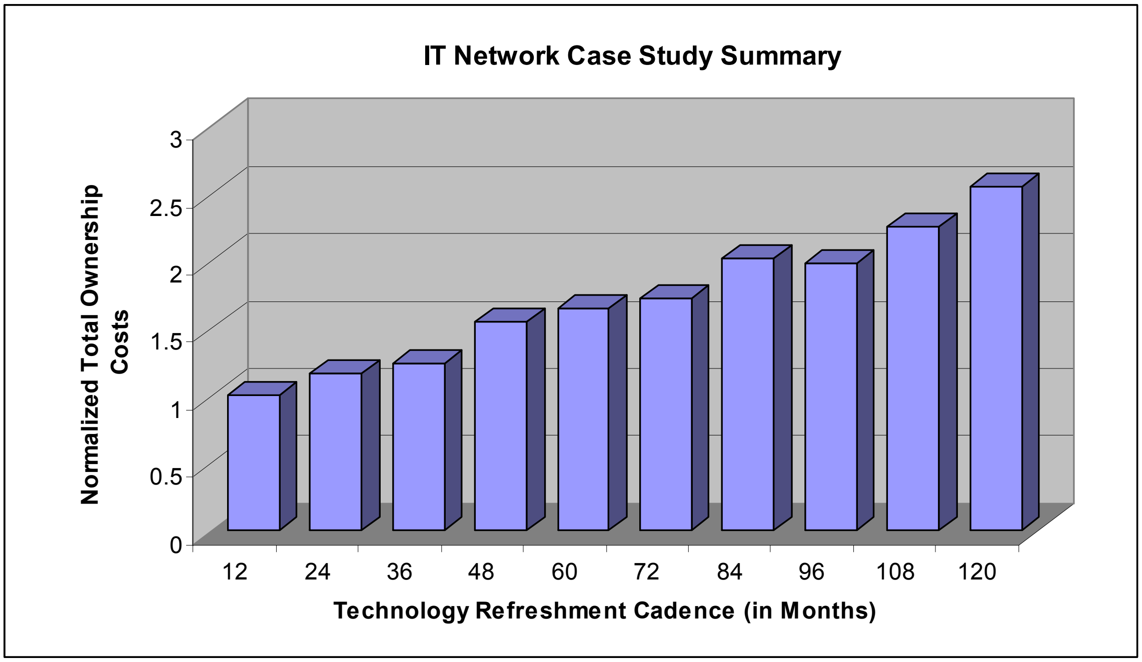

Figure 2. Example R2T2 Output Synthesis for IT Network Change Strategy Affordability

An additional perspective of the output synthesis reveals that the cost of extended system support currently being experienced by the customer far outweighs the cost of planned incremental technology refreshments. This message is significant. The initial reaction of many customers to change is negative. The notion to 'stay the course' and avoid system baseline changes intuitively seems to be the most inexpensive approach. However, it is becoming more and more evident that in high technology systems with fast-changing commercial electronics that scheduled and planned system changes can be implemented much more affordably than artificially maintaining the system baseline with end-of-life purchases, emulation of obsolete parts, or even stockpiling sub-elements of systems (such as for the servers discussed in Section 3). This realization also applies to an unscheduled series of ad hoc changes at each point where obsolescence occurs, which drives more configurations and more compatibility testing.

The actual IT Network system baseline changed 17 times in the 7 years of system deployment. These changes were unplanned and performed asynchronously due to commercial product (mostly workstation and server hardware) obsolescence. They were not coordinated with the other system elements, and often just replaced in the field upon failure. This resulted in many configurations active simultaneously and significant configuration and compatibility testing. Since there was not a stated program plan for change and update, the system is required to undergo a complete overhaul in 2005-2006 that is nearly equivalent of a full system redesign and redeployment. So, what can be learned?

By using a model year concept, there would be only seven refreshed system configurations through the 8-year deployment period. The compatibility of the hardware and software would be known, tested synchronously and deployed. This represents enough configurations to keep the IT Network systems viable and yet few enough configurations to be affordable. It is a reasonable ball park assessment that the potential client savings is conservatively 3:1 by implementing the planned annual model year concept.

The final determination, over a system life cycle, is to understand changes in the system capacity available resulting from each planned system refreshment. The fast-paced system elements (workstation and server hardware) are doubling every 18 months, and thus over the period from 1997 to 2023, there will be on the order of 17 technology doublings, which can result in a performance capacity gain of 131,000 times. This kind of system potential could be leveraged within a planned window to provide for any technology insertion functional needs.

Section 5. Conclusions and Recommendations

The IT network enterprise recommendation is for an annual change cadence which is appropriate for the initial baseline products and technologies. This pace of change is a compromise between meeting the fast changing needs of the system workstation and server hardware and also avoiding unnecessarily frequent asynchronous system changes. Any system life cycle will need to balance the costs of change with the costs of supporting an aging system. Finding this balance provides the customer with the optimum affordability while maintaining system viability. This result is even more important with globally dispersed systems.

In addition to the affordability focus of system change, there is a second dimension for any changes to a system baseline. This is the need to understand the impact of the change on system performance capacity. Since each change will result in some effect to the system capacity, it is critical to understand how much change results. This capacity growth may then be used for a number of possible system advantages; such as increased functional capability, for improving system availability through element redundancy and reconfigurability or for simply reducing the ownership costs for deployment and support. The system architect needs to estimate how much capacity is available to leverage and when in the life cycle will it be available. In the case study, each new product capability improvement was implemented regardless of whether or not it was needed or critical to the system mission.

An interesting third conclusion focuses on the perceived organizational need for maintaining a single operating system (OS) architecture (desktop and server) across the network enterprise. The perception was driven by "it's easier to maintain one operating system version than two or more." In the case study and as a result of this misconception, hardware and software obsolescence contributed to increased refresh expenditures due to hardware failures at sites where the refresh was not yet complete. Expenses ranging from shipping to obsolete equipment refurbishment and logistical management resulted in costs which could have been avoided by a more adaptive architecture. To summarize, consideration of maintaining a single OS architecture strategy across the system network may not be necessary or even feasible due to the geographical dispersion, configuration testing and deployment considerations. While managing a single OS (i.e., Windows 95, etc) appears to be easier, using this strategy for fast changing commercial IT equipments may prove less efficient versus a sound refresh strategy that leverages available commercial technologies with two or more simultaneous OS versions.

The R2T2 methodology employed by this paper is applicable to each of the various system hierarchy levels. It can be applied at the lowest product or technology level and again at each level hierarchically up to the top-level system of interest. The output synthesis provides an understanding of the optimal change cadence, and both the cost and the performance capacity realized at each change point. The final working output is the identification of which study elements will change in each change point, and also to provide an estimate of how extensive that change is based on the technology curve that describes each element. This information can be used to plan the technical direction of the actual change, plan for the necessary staffing skills, plan for the needed lab space and test equipment and estimate the cost necessary in a given change year. From this information, a reasonable and defendable program plan for system evolution can be developed and documented.

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Privacy Statement: Specific reference to the network contractor and the user community has been removed for the privacy of the two participating organizations, since the study relevancy is completely captured solely via the technical aspects. This described IT network could be deployed in any number of viable applications, thus it is immaterial whether the case study represents a commercial system, a US government network or Department of Defense connectivity.

Annex A

Technology Management and Forecasting Definitions

Planned, synchronized, and cooperative system refreshments executed in accordance with an affordable change strategy improve system-wide product availability and commonality to the greatest extent possible. The following four definitions provide a detailed framework to allow for consistent discussion and interpretation:

System Architecture Change - Some Technology Refreshments and Insertions cannot be integrated into the existing system architecture due to complexity of the functional architecture mapping. Thus, for these changes to be incorporated, the system physical architecture must also evolve, or be refreshed to stay viable. This represents a more profound system change, it is typically the most expensive, and however, it usually comes with the greatest system performance (or capacity) improvement. As an example, a missile defense system architecture may be based on an "interrupt scheme", meaning that the system (and processing segment) sits and waits for an event to occur. When an event occurs, then the processors attack the problem, and then go back to a wait state. Today, some missile defense systems architectures operate in this way. This interrupt approach physically requires dedicated processors for each defense weapon (with appropriate 2N redundancy) to be incorporated into the system. In contrast, the system designer may choose to change the system architecture to an integrated "N+1" architecture (distributed processing with only a single additional redundant resource). This option is hardware efficient, necessitates a layer of software application management, and offers either the same functionality as before (thus a Tech Refresh), or offers additional capabilities (thus a Tech Insertion). It would be easy to categorize this architecture change as a Tech Insertion. However, this change might be made solely for Tech Refresh reasons, and choose not to provide functional enhancements, but only an architecturally different solution.

System Configuration Management - Different system instantiations will be developed along the road of system evolution in response to the technology evolution needs of the commercial products that make up the system. As these system variants are developed, the system designer must make a decision regarding the extent of backward compatibility of each new system technology variant. In the ARCI case study, it was determined that each new software configuration instantiation will be required to run the two previous hardware system levels, thus allowing older deployed systems to reap the advantages of the newer software applications (technology insertions). However, this design decision also means that each new hardware configuration must plan for design margin to accommodate newer and larger software configurations over the technology refresh period (2 years in the ARCI case study).

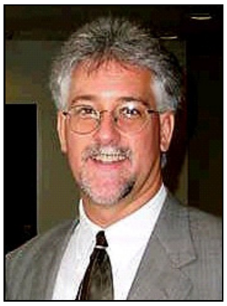
Technology Evolution - Refers to two types of migration. First is evolution within a specific product line, such as a software package going from V1.0 to V2.0, etc. The second migration refers to the technology changing from its current accepted form to something different/new. An example of evolution would be the transition from wire-based Ethernet networking to Fiber Optic Ethernet (or other) Standards. Both of these technologies implement the Ethernet network connectivity, but do so according to very different open system standards. Technology evolution does not mandate that change must take place, but rather offers a system opportunity to the designer. The question that always faces the business and engineering leadership is when and how (and if) to transition from the current deployed baseline.

Technology Insertion - Similar to the technology refreshment, technology is used to intentionally advance the capabilities of the initial system. It is an expected reality that the functionality of the system will not stay constant over time, but will advance. These enhancements can be in the form of growth or migration to newer technologies. In either event, the decision to perform a technology insertion is disjoint from the decision to perform a necessary technology refreshment just to keep the system operationally viable.

Technology Refreshment - Means the refreshment of the system to avoid upcoming predicted obsolescence issues, while keeping the original functional requirements as a constant. As an example, if it takes five Pentium1 desktop computers to process the necessary information for a function, then a technology refreshment to Pentium 4 2GHz computers would not take five to satisfy the technical requirement. It is possible that just 1 or 2 would satisfy the requirements, thus allowing for significant savings (in weigh, power, volume, cooling and cost) as a result of information technology advancements. With all of the challenges and difficulties that commercial products create, here is the tangible reason for taking on their burden. An additional complexity is that not all technology refreshment changes will affect cost with the same magnitude. Some changes will be minor (as in a component for component replacement, including minor or no testing), and others will be major (such as when an operating system or connectivity bus is changed). A solid program plan should consider both the fact that a change needs to occur in a given time period, and also address the magnitude of this change for that point in time.

Author Biographies

Thomas E. Herald, Jr.: Tom holds a Masters of Science in Electrical Engineering from the University of Maryland, and earned his BSEE from the University of Pittsburgh. He is currently pursuing his doctorate in Systems Engineering from Stevens Institute of Technology in Hoboken, New Jersey. As a part of the Systems Design and Operational Effectiveness Program within the Systems Engineering and Engineering Management School at Stevens, the focus of Tom's dissertation research is on providing the Systems Engineer of a large-scale network-centric system with a closed-loop integrated approach for the development and definition of technology and obsolescence management. Large, network-centric systems utilizing legacy systems, integrating newest technologies and involving highly diverse joint-forces and international stakeholders has increased the magnitude and complexity of systems development and driven the need to provide the System Engineer with additional bottoms-up tangible decision and optimization support.



With 22 years of industrial experience at IBM Federal Systems, Loral, and now Lockheed Martin, Tom is currently a Senior Staff Systems Engineer working for Lockheed Martin as a part of the Maritime Systems & Sensors business unit and is responsible for adapting and evolving the traditional custom systems processes for COTS-based systems integration programs. His primary interests are the tangible linkages of program supportability parameters, technology refreshment and insertion considerations into the systems engineering development process.

Jason S. Seibel: Jason Seibel has been in the systems engineering and operations Information Technology sector for over 10 years. He has participated in the design, installation and operation of multi-million dollar private, government and telecommunications data networks. He has expertise in a wide variety of industries including pari-mutual wagering, high availability dot.com point-of-presence, Telco high speed data backbones, data centers, commercial LANs and WANs as well as a myriad of other IT systems.

Mr. Seibel holds a Bachelor of Science in Computer Information Science from the University of North Florida, a Master of Science in Systems Engineering from the George Washington University. He is currently pursuing a Doctorate of Science from George Washington University, School of Engineering and Applied Science. His dissertation is focusing on the planning and forecasting of large scale, systems-of-systems Information Technology challenges that face organizations today.