Chapter 4

4.0 Life Cycle Support and Cost Analysis

Chapter 4 will present the accomplishments to-date in establishing a Life Cycle Cost (LCC) projection for the AN/BQH-7/7A EC-3 upgrade. The LCC support model presented will include the general methodology for determining total LCC on systems utilizing COTS and NDI items for technology upgrades and/or technology insertion refresh initiatives.

The EC-3 IPT discovered that there were two main problems, or obstacles, preventing government agencies from determining accurate LCC projections. The problems are somewhat less for private industry because they have the leverage to establish professional relationships, over time, with many of their vendors. The government, on the other hand, has historically been restricted to awarding contracts to the lowest bidder. However, acquisition reform initiatives and “best value” contract practices are slowly changing this environment.

The two main problems that were discovered by the IPT team were;

- the over-optimistic support projections given by vendors whose main goal is to sell you their product (that is, if they even give you a support projection),
- the ever-changing nature of the marketplace today where rapid advances in technology, coupled with the need to respond rapidly to market pressures, results in vendors eliminating the production of products showing low demand and replacing them with differently configured, or entirely new, items.

The second problem is made worse by vendors who rarely communicate their intentions and market plans to customers for fear that their market strategy would be compromised. Two examples of this problem that the IPT experienced firsthand were;

(1) The first was when Sippican ordered a half dozen commercial PC computers for their company. The orders were placed at the same time. On incoming inspection of the new computers, Sippican noted that some of the electrical components used in the computer were of different configurations. Some component changes where not simple pin-for-pin replacements but rather complete board redesigns.

(2) In the second case, after conducting a market survey for displays; we settled on a display model we felt met our design requirements. The vendor was very interested and gave us a price with the statement that the display would be supportable for many years to come. Sippican bought one display for form, fit, function testing. Less than three

months later when we went back to the vendor to obtain a price for a quantity buy, the vendor informed us that the model would be discontinued and that a direct form, fit, function replacement would not be made available in it's place!

4.1 COTS versus Build-to-Print (MILSPEC) Systems

Government and non-government procurement offices have been experiencing an increasing escalation in new system procurements over the last several years. This increase has been in unison with a declining defense budget. The direction today from DoD is to do more with less. Therefore, acquisition program offices like PMS415 have been looking at innovative ways to reduce system costs. COTS and NDI technologies are seen as the most likely means to accomplish this cost reducing goal; not only in the nearterm, but throughout total system ownership Life Cycle Cost (LCC). Employing commonality and open systems architecture initiatives in unison with COTS and NDI implementation seems to be the win-win solution. But is the battle to reduce system procurement and support cost really being won? If the answer is yes, then where is the supporting historical data (i.e., the proof)? The answer to this question is actually straightforward. There are very few, if any, fielded systems from which a conclusive analysis on LCC can be drawn because of the lack of historical data for analysis.

Today's belief in the benefits of using COTS and NDI items is illustrated below in Figure 18 where tradeoffs between the benefits versus the risk of system cost, system lifespan, competitive procurement market, available vendors, and ease of technology insertion and/or refreshes through interchangability is being studied and analyzed. The use of Military Specifications (MILSPECs) in system procurement is cost prohibited today for most new systems procurements. The commercial environment have many more potential benefits to offer.

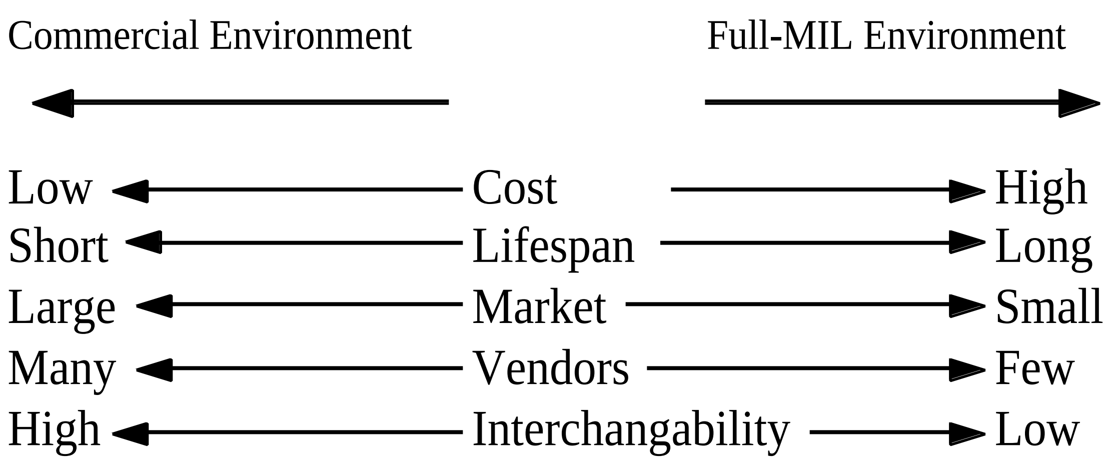

Figure 20 - Commercial versus MILSPEC Procurement Comparison

To date, there are very few examples of actual cost savings in initial procurement cost. However, the forecast for future LCC reductions continues to be optimistic. For a program using COTS and NDI items and projecting LCC savings during preliminary design; to say these cost savings will also apply to the operation and support phase of a system is really nothing more than a hopeful “best guess”. Only time will tell. With COTS/NDI technology and configurations changing daily, as illustrated in Figure 19, who knows for sure what the full LCC saving (or LCC cost increase) will be. Today’s analysis are in actuality nothing more than unproved projections, or are they?

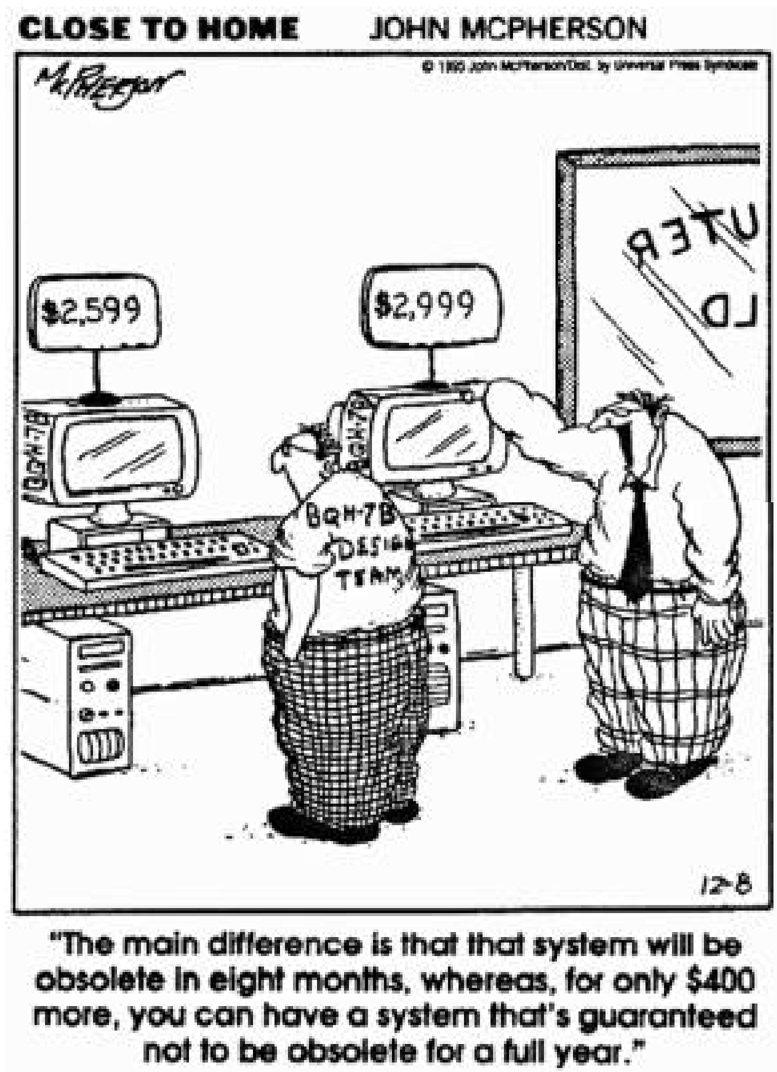

Figure 19 - Cartoon Depicting the Rapid Pace of Technology Changes

A detailed AN/BQH-7/7A EC-3 recorder LCC analysis was slow in starting because of these unknowns. The benefits versus risks for programs using COTS and NDI technology was and still is just being determined. To complicate the LCC analysis is the drive to implement commonality and open systems architecture initiatives in unison with most COTS and NDI technology insertion initiatives. As stated above, historical LCC data to date is limited and examples of fielded programs from which benefits versus risk conclusions can be drawn are practically nonexistent.

Our IPT conducted a survey of programs that (1) had implemented COTS and/or NDI technologies in the past and (2) had or were developing LCC models to better predict future costs and for risk mitigation. Our survey focused in on the AN/SQQ-89 Acoustic Intercept Program. We proceeded to leverage our LCC analysis efforts from the lessons learned from this program. Whereas our proposed EC-3 Kit was based on PC industrial standards, the AN/SQQ-89 system was based on VME computer backplane interconnects, FDDI networking, POSIX based operating systems, X-Windows graphics, with a SQL based database. However, we felt that the COTS/NDI LCC cost projection process would be somewhat independent of architecture. A proven and successful methodology for one should be successful for the other.

Today, commercial product designs and configurations change rapidly as compared to unique military designed products. Whereas the expected technology life span of disk drives is one year, it is five to seven years for computer processor circuit cards (see Figure 20).

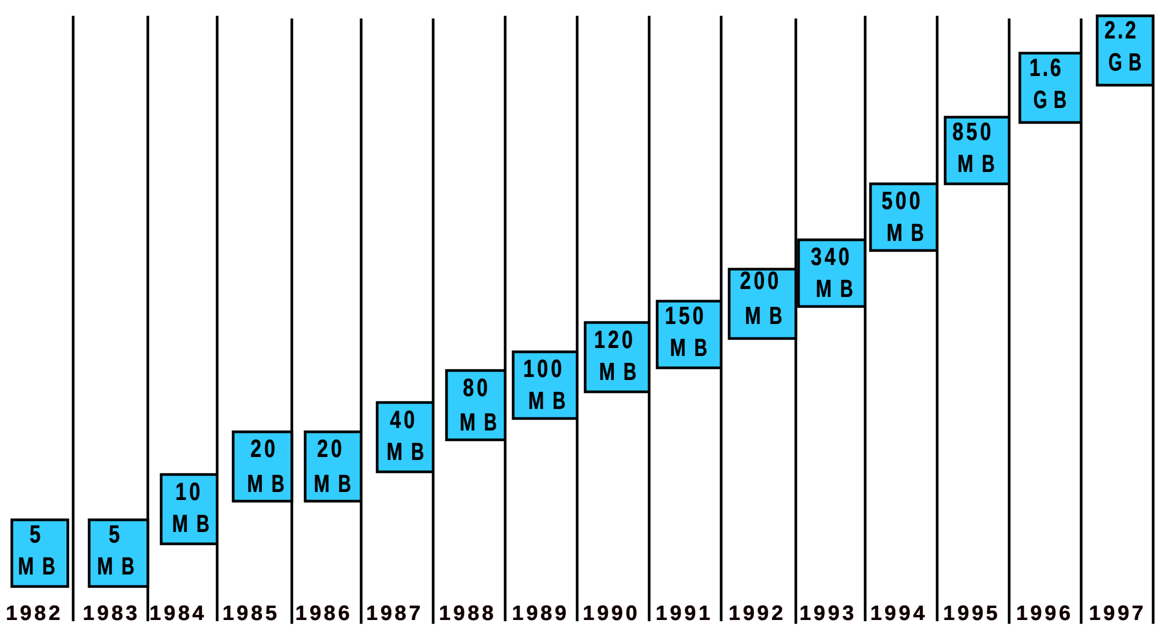

Figure 20 - Hard Drive Evolution - Typical PC Hard Drive Capacity by Year [9]

Because of the rapid technology evolution, and as the commercial product content of military systems increases, the amount of product changes throughout the system life will also increase. Figure 21 is a relative comparison of the amount of system changes for a build-to-print system versus a COTS based open system. The amplitude or y-axis value is relative. Figure 21 illustrates the peaks and valleys that can be expected in comparison between a build-to-print (MILSPEC) system and that of a COTS based open system. Because of the rapid pace of COTS configurations changes, technology refreshes and upgrades is required in keeping pace with available technologies. This also drives the requirement for an open systems architecture (OSA) modular design for ease of future technology insertions.

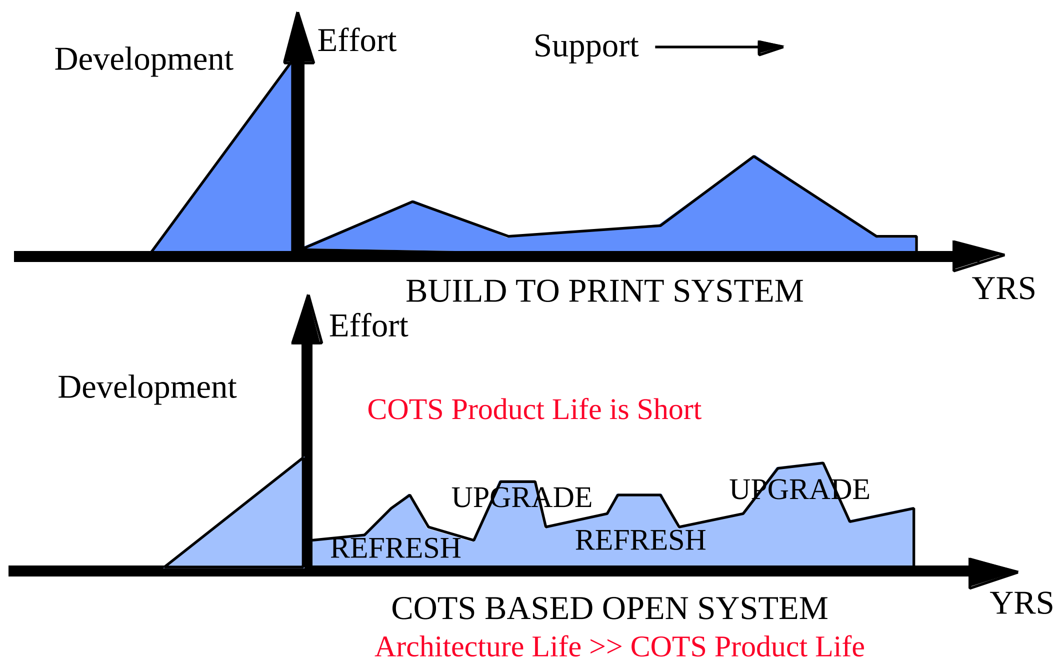

Figure 21 - Nominal Life Cycle Support Comparison between Build to Print and COTS Based Systems

The introduction of COTS changes the support and cost requirements from one in which the Navy has design control of the products to one in which the Navy has to react and respond to product changes in the commercial market. It is also impractical to control the configuration of COTS product designs and to maintain product standardization within the system for any length of time unless a robust open systems program is adhered to. The form, fit, and function of the interfaces defined in the standards, not the individual product lines, become the fundamental system building blocks and the point of standardization through the system life-cycle.

Naval Surface Warfare Center (NSWC), Crane Division Code 6121, developed a process for developing an open systems COTS and NDI cost and support model for programs implementing COTS and NDI componetry in technology insertions initiatives.[10] The process includes:

(1) Identifying, documenting, and baselining the interface features used in the system via a process called profiling,

(2) Characterizing and verifying a product's open system behavior with respect to the baseline via conformance testing,

(3) Evaluating and verifying upgrades/technology insertions with respect to the open system baseline.

NUWC applied this to both the AN/BSY-1 and the AN/SQQ-89 programs. The AN/BQH-7/7A EC-3 IPT chose to leverage off of the "lessons learned" from the NUWC analysis that was conducted on these two programs when determining a LCC Cost and Support Model for the AN/BQH-7/7A EC-3. The EC-3 LCC Cost and Support Analysis will be conducted using the process illustrated in Figure 22 below and discussed in the following two sections.

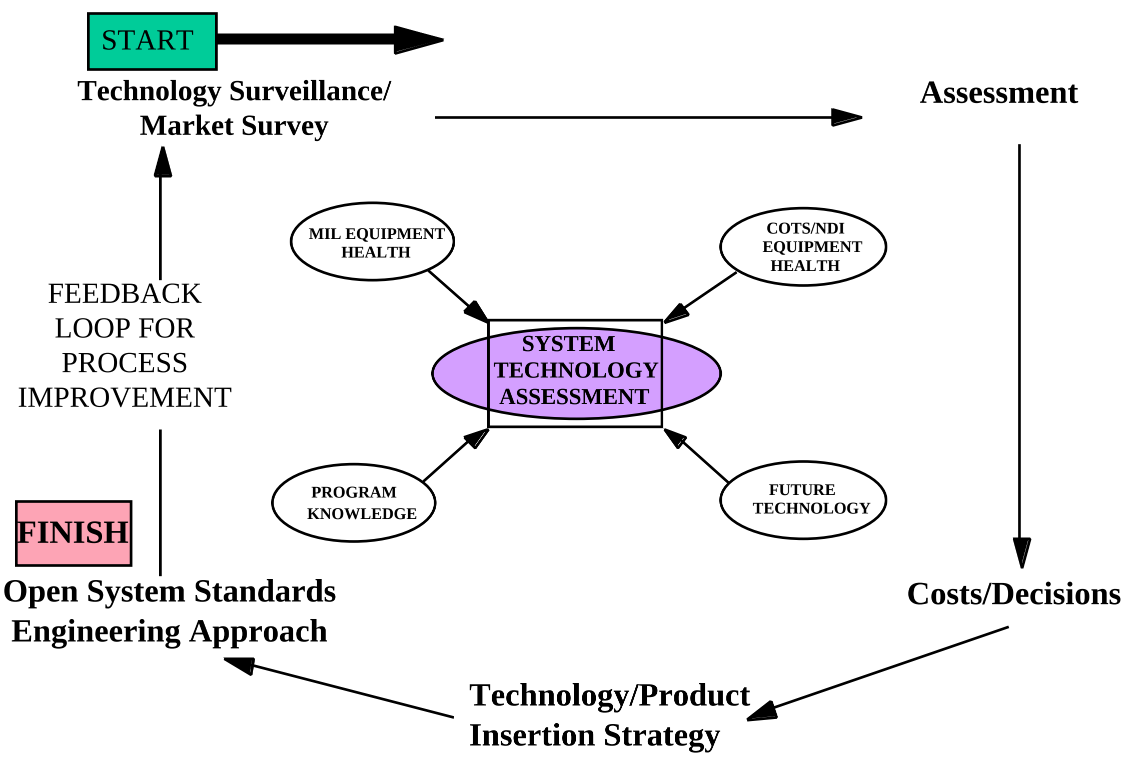

Figure 22 - System Technology Assessment Process

4.2 Example of Operation and Support Cost Savings (AN/SQQ-89 Program)

A Market Survey was performed on a number of boards nearing or at the point of parts obsolescence in the AN/SQQ-89 System. The replacement cost was analyzed and the results tabulated in Table 10 below.

Table 10 - AN/SQQ-89 Total Product Replacement Cost

No.	LRU NOMENCLATURE	TYPE	COST of LRU	SUPPORTABILITY / LOGISTICS COSTS	ENGINEERING COSTS	TOTAL COSTS PER ITEM
1	Enclosure					
2	VME Board, SBC	B	$7,000	$183,300	$476,000	$659,300
3	VME Board, NTDS	B	$5,000	$188,300	$264,000	$452,300
4	Tape Drive, 250 MBYTE	A	$250	$101,550	$141,500	$243,050
5	Hard Drive, 600 MBYTE	A	$500	$102,800	$149,000	$251,800
6	Floppy Drive, 1.44 MBYTE	A	$100	$100,800	$97,000	$197,800
7	Transition Module and P2 Adapter	B	$250	$101,550	$101,500	$203,050
8	Paddle Card	B	$250	$101,550	$108,500	$210,050
9	FDDI Dual/I/O Card	B	$5,000	$173,300	$376,000	$549,300
10	BQH-7 Card	B	$10,000	$198,300	$566,000	$764,300
11	ETHERNET THINNET Transceiver A3	A	$600	$103,300	$102,000	$205,300
12	RS-232/RS-422 Converter A2	A	$100	$100,800	$134,800	$235,600
13	LYNX OS MVME167, V2.2.1	B	$7,500	$185,800	$759,000	$944,800
14	LYNX TCP/IP MVME167, V2.2.1	B	$1,500	$155,800	$219,000	$374,800

The assumption used in the cost analysis was based on having to replaced the boards one-at-a-time as each board neared total parts obsolescence. The cost analysis showed a fully loaded (actual cost) cost of;

$5,291,450.00

Next, a Board Availability and Support Characteristic Analysis was performed to establish a support characteristics curve to determine the behavior dynamics of parts support degradation patterns of parts once thought to be supportable for the life of the system. Figure 23 shows the shape of a typical support characteristics curve.

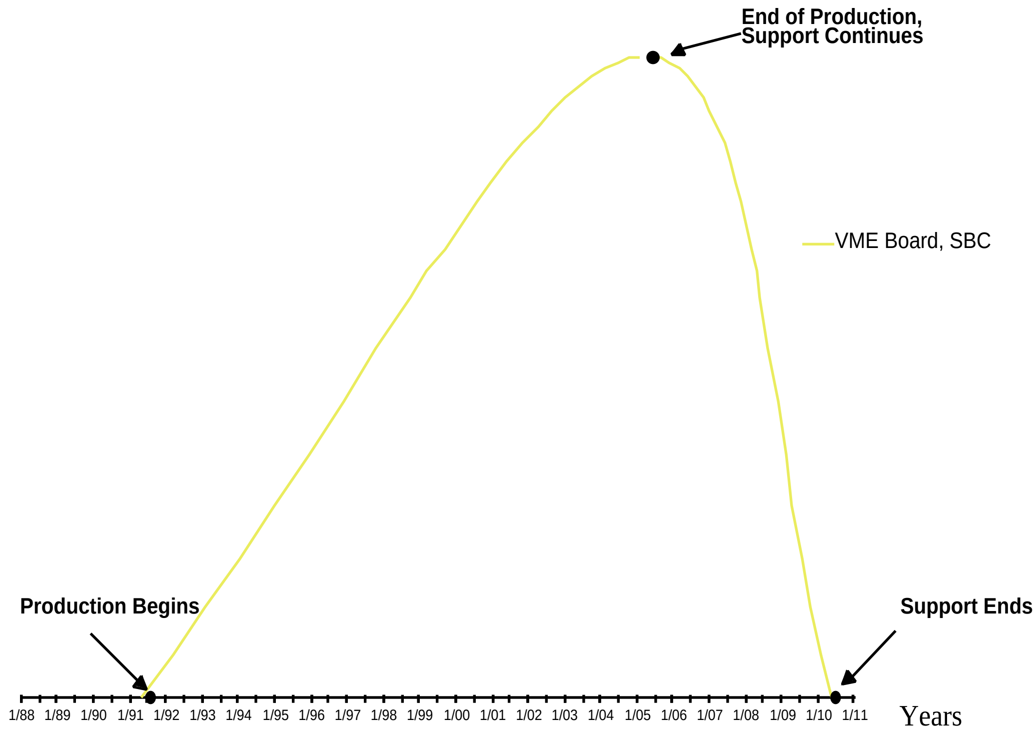

Figure 23 - Board Availability and Support Curve Example

Taking this study one step further, a support characteristic curve was developed for each of the boards listed in Table 10. Each board contained different unique parameters that were driving the boards to parts obsolescence. The board unique parameters include when the board was produced, quantity produced, the analog or digital components selected for use, component vendor support policy, unique stress screening requirements, robustness of each board design, etc. The y-axis represents production quantity over time. Exact production quantity figures are not as important as;

- When Production Began
- When Production Ended
- When Support Ended

Figure 24 shows an overlay of all of the support characteristic curves developed for the boards listed in Table 10.

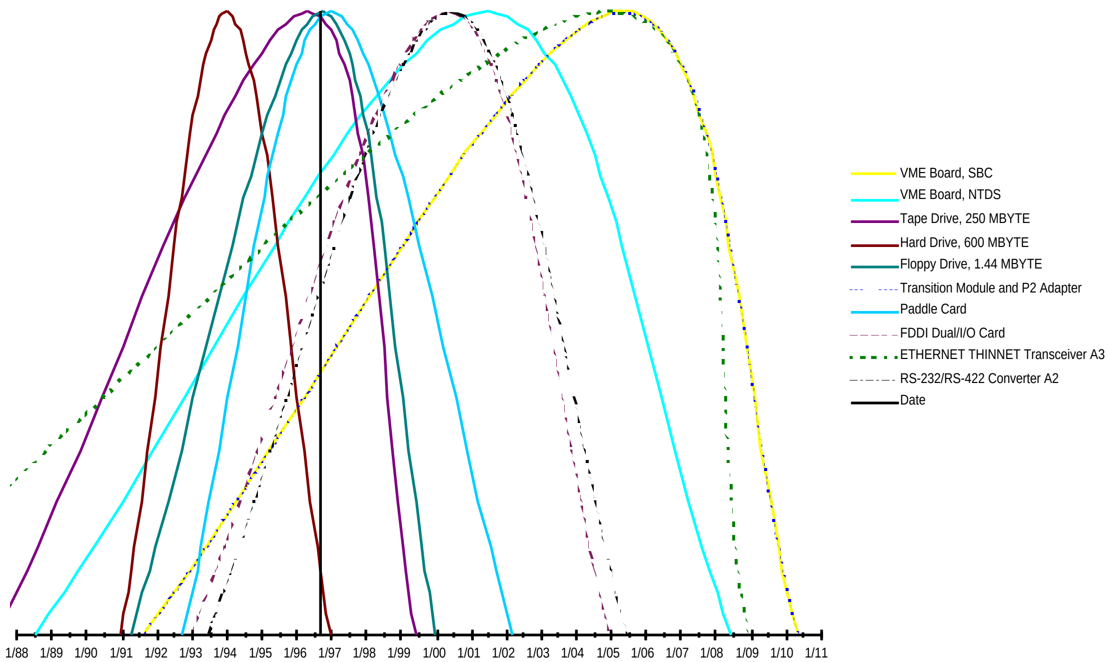

Figure 24 - Product Life Cycles Identified from Market Survey

By using the information obtained from the support characteristics curves above, a one-time technology insertion push was planned for resolving all of the parts obsolescence problems at once rather than the one-at-a-time serial approach used in Table 10. The characteristic curves were carefully analyzed and the year 2001 was selected. The cost of replacing all of the boards nearing or at parts obsolescence in 2001 was calculated. This cost analysis was compared against the Table 10 cost analysis which took the serial approach to board replacement. Figure 25 illustrates and a discussion follows which presents the projected cost savings anticipated when this methodology is used.

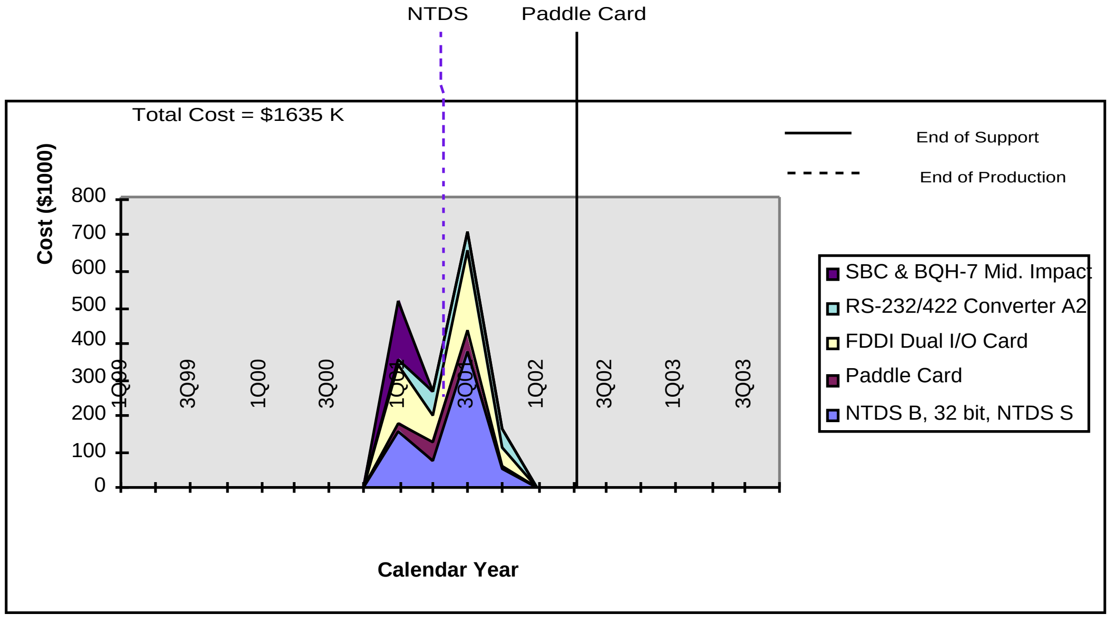

Figure 25 - Collective Technical Refresh in Year 2001, Cost vs. Time

The savings from using the one time, well planned technology insertion approach is substantial. The assumption used in this cost analysis was based on replacing all of the boards at one specific point in time and having a well-managed consolidated replacement plan and procedure in place. The second cost analysis showed a fully loaded (actual cost) cost of;

$1,636,000.00

Direct Cost Savings to the Program of;

$5,291,450.00 - $1,636,000.00 = $3,655,450.00

4.3 AN/BQH-7/7A EC-3 Life-Cycle Cost (LCC)

The question facing program managers today when implementing COTS and NDI components in major system upgrades, technology insertions or refresh initiatives are; "How does one project the benefits versus the risk over time with such little historical data to draw from?" The above AN/SQQ-89 example presents a methodology that can be easily applied to any program today.

Therefore, we plan to continue leveraging the AN/BQH-7/7A EC-3 LCC and Support Analysis from the lessons learned from the AN/SQQ-89 approach. We believe that the LCC cost process used for this program provides a sound methodology and logical process from which the AN/BQH-7/7A EC-3 program will benefit. This process will be used to develop a Life Cycle Cost and Support Analysis Plan and a Technology Insertion Program Plan.

Chapter 5

5.0 Summary

A support problem with the fielded AN/BQH-7/7A bathythermograph recorder was discovered through normal monitoring of several key indicators (metrics). By plotting actual support data obtained from the recorded metrics, a clear trend was discovered that indicated the program was rapidly moving toward a problem with parts obsolescence. The metrics monitored were;

1. Number of ECNs Presented Over Time,
2. Fleet Casualty Reports (CASREPs),
3. Number of On-Site Technical Assist Fleet Request,
4. Navy Supply System Fleet Requisitions Requests for Parts,
5. Contractor Depot (Sippican) Repair Activity.

An Integrated Product and Process Development (IPPD) Integrated Product Team (IPT) was formed and challenged with the task of conducting a further study of the key indicators and to recommend an affordable solution to the problem. The team concluded that parts obsolescence was increasing in an exponential matter over time and that the mechanical components used in the recorder (strip chart and cassette recorder) were wearing out and failing at an increasing rate. It was also determined that the parts obsolescence problem was not just limited to the mechanical components. The analog electronic components were also obsolete or rapidly becoming obsolete.

In March 1995 the IPT team proposed the development of an affordable EC Kit based on the Non-Developmental Item (NDI) Sippican Mk-12 Data Acquisition Card. A detailed requirements analysis to review all existing requirements began. To gather user input to determine current requirements, a series of several user meetings and presentations were conducted with the Fleet. The functionality of the Mk-12 was presented at each meeting by running the software on a laptop computer. Using the Quality Function Deployment (QFP) and Analytic Hierarchy (AHP) techniques and principals discussed in Section 3.4.1, a list of desired requirements were established. Each requirement, both existing and desired, were looked at individually. Through design synthesis, the most feasible, affordable, and easily supportable EC Kit design was proposed to the IPT. A detailed functional analysis and hardware allocation was conducted. Through the resulting tradeoff studies and analysis, a Bill of Material (BOM) was developed and proposed. The Table 9 BOM represents the detailed design that will be used for the first Pre-Production Unit (PPU) prototype. Final requirements were documented in a Prime Item Development "Type A" Specification (PIDS) [Performance Specification].

The EC Kit was presented as the AN/BQH-7/7A EC-3 to the Fleet users and was favorably received and highly endorsed as indicated in Appendixes A and B. This success was achieved by following a logical series of systems engineering processes which are presented in Chapter 2.

5.1 Conclusions

From a systems engineering perspective, the AN/BQH-7/7A EC-3 project was an ideal subject to choose and to report on for meeting Virginia Tech's final requirements for a graduate degree in systems engineering. The systems engineering processes presented in Chapter 2 were not just discussed; they were implemented in a real Navy program to resolve a very real support problem for an important Navy system.

This report also presents a methodology for handling the uncertainty and unknowns one faces when attempting to determine accurate total life-cycle cost projections in programs utilizing Commercial-off-the-Shelf (COTS) and Non-Developmental Item (NDI) components. The potential benefits of using COTS and NDI componentry are enormous if planned properly and implemented wisely.

There is still a lot of engineering analysis yet to be performed on the AN/BQH-7/7A EC-3 system, but the hard part is over. Prototype funding has been identified and assembly of the prototypes will begin in June 1997. Because of the detailed systems engineering analysis conducted up front in design, it is planned to build and test only one Pre-Production Unit (PPU) prototype. The other three EC-3 units will be assembled as Production Representative Units. The Open System Architecture (OSA) modular design will allow us to simply remove the strip chart drive drawer and replace it with the active matrix high resolution color monitor. The analog circuit card drawer will be removed and replaced with the digital circuit card drawer along with the removable hard drive. The front of the new circuit card drawer will hold the keyboard and trackpad. The cassette tape will be replaced with a floppy disk drive. The result will be an affordable, easy to support and maintain, easy to implement, solution to a real Fleet problem. EC-3 will improve the performance of the recorder and the user's capability to measure the ocean environment.

Notes and References

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