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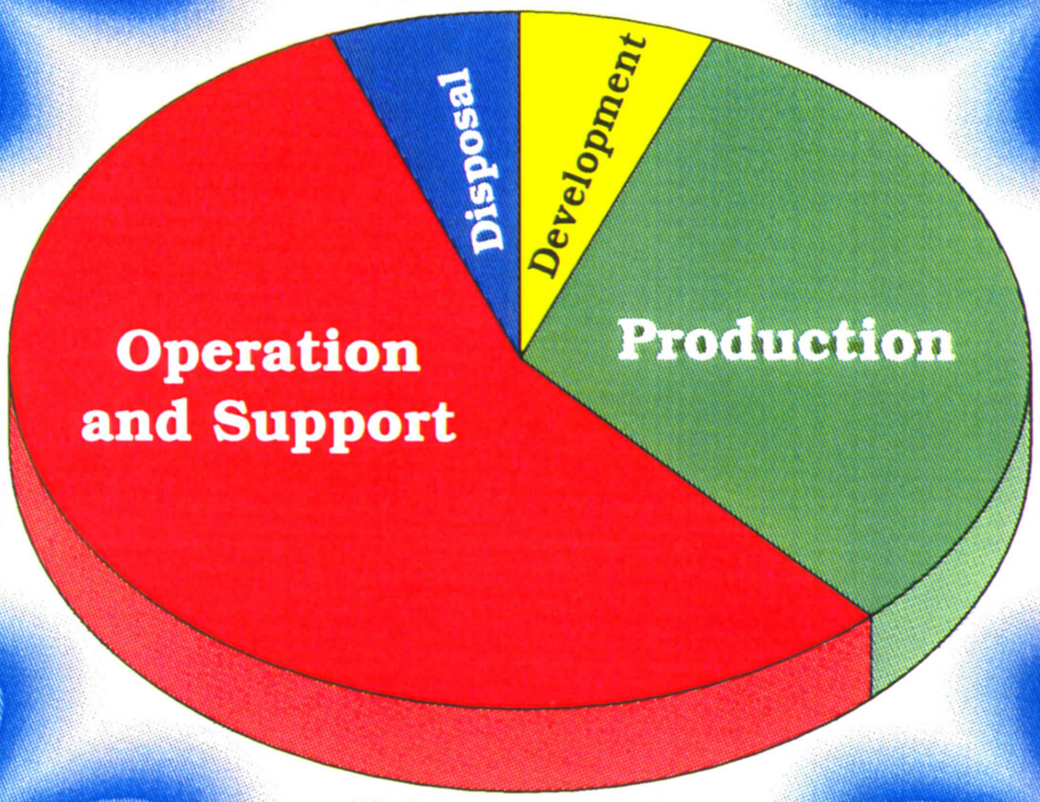
NRAC

Naval Research Advisory Committee Report

Life Cycle Cost Reduction

November 1995



OFFICE OF THE ASSISTANT SECRETARY OF THE NAVY
(RESEARCH, DEVELOPMENT AND ACQUISITION)

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LIFE CYCLE COST REDUCTION
EXECUTIVE SUMMARY

PURPOSE OF STUDY

During the spring of 1995 a study panel was assembled under the auspices of the Naval Research Advisory Committee (NRAC) to "assess the impact of science and technology (S&T) on life cycle cost (LCC) initiatives of current Department of the Navy (DON) systems and projected DON acquisition programs." In the course of the study, the Panel soon found that although numerous opportunities existed for S&T investment to beneficially impact LCC problems, the underlying problem was a lack of visibility and consideration of LCC implications of decisions made early in the requirements definition and concept development phases where LCCs are largely determined. This general lack of visibility of LCCs was found to continue throughout the life of most systems.

OBSERVATIONS

Although always important, LCCs have become particularly critical as DON budgets have declined in recent years, while the tempo of naval operations has actually increased. Operations and Support (O&S) costs have thus remained almost constant, while the bulk of the budget reductions were absorbed in the procurement budget. If allowed to continue, this situation will prevent the DON from re-capitalizing its force structure. Given that the procurement budget has long been closely managed and has recently suffered such substantial reductions, the O&S budget segments which currently dominate the DON budget represent the greatest potential for cost savings in the foreseeable future.

Although project specific LCC reduction initiatives were reviewed for both operational systems and systems under development, the Panel was unable to identify a systematic DON-wide process for reducing O&S costs. In addition to lack of timely availability of historic LCC data, the DON has little, if any, ability to predict future LCCs, especially for systems utilizing revolutionary new technologies for which no historic cost data exist. Most importantly, DON leaders have not formulated and articulated an LCC reduction strategy.

CONCLUSIONS

The Panel concluded that such an LCC reduction strategy should make use of the emerging simulation-based design (SBD) environment to identify LCC drivers in conceptual system designs and to project LCC implications of design alternatives. Since it is anticipated that more LCC reduction opportunities will be identified than can be reasonably exploited, it is necessary that the DON LCC reduction strategy provide guidelines for selecting LCC reduction investment opportunities based upon trade-offs between technical and programmatic risk and potential return on investment.

RECOMMENDATIONS

The recommendations of the NRAC LCC Reduction Panel are that the DON must take steps to make LCCs, both historic and future, visible to all decision makers in the requirements, development, production, and O&S communities. Furthermore, DON leadership must develop and articulate an LCC reduction strategy. DON S&T investment can then be aligned to support this strategy.

It is recommended that specific programs be carefully selected to develop and demonstrate the SBD LCC reduction methodology. Such methodology should be directed to make effective use of integrated project teams wherein expectations, responsibilities, and resources are clearly identified. It is essential to commence control of O&S early in the acquisition process. In order to accomplish this, O&S costs must be given the same visibility as military performance and procurement costs, and Program Managers must be provided with incentives and resources to reduce O&S costs.

Finally, it is essential to institutionalize the authority and responsibility of the Chief of Naval Operations (CNO) and the Commandant of the Marine Corps (CMC) for acquisition decisions that affect the LCCs of systems in the same way that the CNO and CMC are responsible today for decisions affecting military performance of systems and the DON Acquisition Executive is responsible for decisions affecting acquisition costs.

Life Cycle Cost Reduction Panel Membership

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Vice Chairperson		
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Ronald J. Elliott	LCDR, USN	OPNAV (N43)
ASN(RD&A) Sponsor		
W. A. Earner, Jr.	VADM, USN	DCNO (Logistics)

PANEL MEMBERSHIP

The NRAC LCC Reduction Summer Study Panel was composed of representatives from industry, academia, the Navy science and technology community, retired Navy and Marine Corps officers and an Army Senior Systems Analyst. This was the first NRAC Panel to have the benefit of a foreign navy representative, and the Panel found the contribution of Captain Jonathon Reeve of the UK Royal Navy to be invaluable. Sponsor of the study was VADM W. A. Earner, Jr., Deputy Chief of Naval Operations (Logistics).

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Terms of Reference
Life Cycle Cost Reduction

Assess the impact of science and technology on life cycle cost initiatives of current Department of the Navy (DON) systems and projected DON acquisition programs.

TERMS OF REFERENCE

In February 1995, the NRAC was charged to "assess the impact of science and technology on life cycle cost initiatives of current DON systems and projected DON acquisition programs." It is perhaps significant that the Panel was unable to identify an official Department of Defense (DOD) or DON definition of life cycle costs. For the purpose of this study, the Panel defined life cycle costs as all costs incurred in the development, production, operation, support and disposal of a system. (See illustration on cover.)

The Terms of Reference for the NRAC Summer Study Panel on Life Cycle Cost Reduction are included here in their entirety.

TERMS OF REFERENCE
LIFE CYCLE COST REDUCTION

GENERAL OBJECTIVE: Assess the impact of science and technology on life cycle cost initiatives of current DON systems and projected DON acquisition programs.

BACKGROUND: With major changes in the defense budget and associated actions to maintain a smaller but equally effective military force, system affordability has become a major element in the decision-making process. Science and technology can have a major impact on life cycle costs, which is the biggest driver of system affordability. Although system affordability has become a major element in the decision-making process, each system must perform the mission it was procured to perform, including operational effectiveness and supportability. DON must be proactive in implementing processes to evaluate science and technology cost trade-offs and effects on downstream operational and support costs to ensure that total life cycle costs and system affordability are visible for timely decision-making.

SPECIFIC TASKING:

a. Review existing life cycle cost models and current life cycle cost initiatives.

b. Identify key areas that would benefit from total life cycle costs and affordability initiatives.

c. Identify pilot projects to evaluate future life cycle cost tracking and analysis.

d. Recommend specific areas where DON should invest to make systems more affordable by reducing life cycle costs and improving system performance through directed/focused science and technology efforts.

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Briefings/Visits

•LCC
- DCNO (Logistics)
- Naval Center for Cost Analysis
- NAVSEA 017
- USD (Logistics)
- USD (PA&E)
- OPNAV N81
- Center for Naval Analyses
- ASN(RD&A)
- NAVAIR
- Royal Navy

•Operational Systems
- Aegis Program Office
- NAVAIR
- NAVSUP
- CINCLANTFLT Maintenance
- Regional Maintenance Office
- Norfolk Naval Shipyard
- United Airlines Maintenance Facility
- NSWC Crane
- US Air Force Materiel
- ONR
- NAVSEA 03
- SH-60 Program Office
- SSPO

•New Systems
- ARPA
- DRPM (AAA)
- SC-21
- Newport News Shipyard
- Carrier Program Office
- Boeing (777)
- PEO (JAST)
- Comanche Program Office
- LPD-17 Program Office
- Boeing (V-22)

BRIEFINGS/VISITS

Between 15 May and 23 June 1995, the Panel held three meetings and made four field visits with the following goals in mind.

- Evaluate the current methods for determining and tracking life cycle costs, and determine DON and Office of the Secretary of Defense (OSD) policy on life cycle costs.
- Examine existing systems within the services for examples of efforts to reduce operating and support costs, track life cycle costs, and to investigate the S&T efforts that could lead to reduced operating and support costs.
- Assess new systems (command and military) for use of LCC prediction tools, determine if S&T investments are required to reduce future life cycle costs, and evaluate performance versus life cycle cost trade-offs being made for future systems.

The Summer Study convened from 17 to 28 July 1995. A detailed agenda for each meeting is provided in Appendix A.

Outline

- **Life Cycle Costs**
- **Operational Systems**
- **New Systems**
- **Conclusions & Recommendations**

<u>OUTLINE</u>

This report is organized in four sections, with the first section defining the LCC problem and treating relevant definitions; it provides substantive build-up and determination of life cycle costs. The second section addresses LCC problems and initiatives specific to existing, operational systems. The third section treats LCC issues of new systems, and the fourth section presents the Panel's conclusions and recommendations.

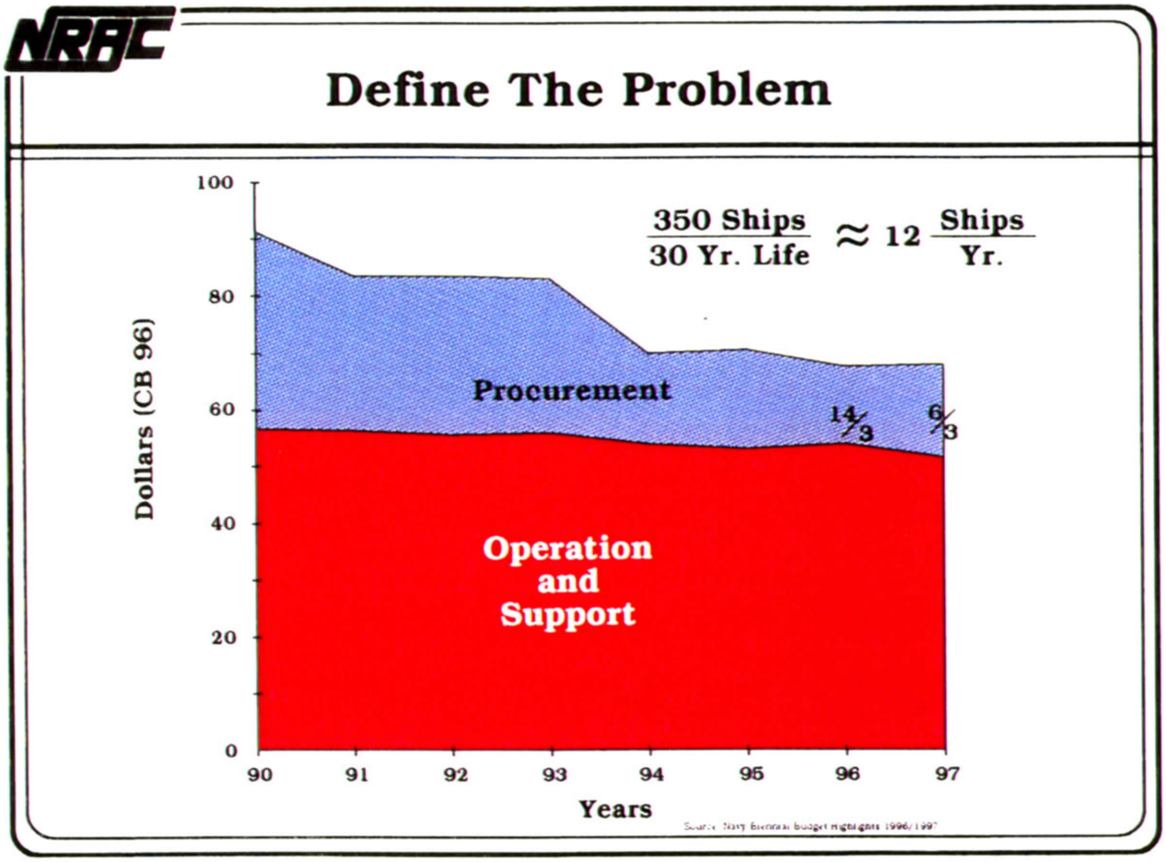
Life Cycle Costs

"The Department of the Navy does not have a system in place to track life cycle costs in a timely way. Our ability to predict life cycle cost implications of procurement and operations trade-offs is extremely limited."

VADM William A. Earner, Jr.
Deputy Chief of Naval Operations (Logistics)

LIFE CYCLE COSTS

At the outset of this study the Panel Chair asked the study sponsor for a detailed breakdown of life cycle costs for a typical mature Navy system. When informed the DON was unable to provide such a breakdown, the Panel was forced to look beyond the Terms of Reference for the study in order to understand the DON's present inability to characterize the whole LCCs of a system in an accurate and timely way. The ability to accurately represent both past and future aspects of life cycle costs is central to any effective LCC management system.



DEFINE THE PROBLEM

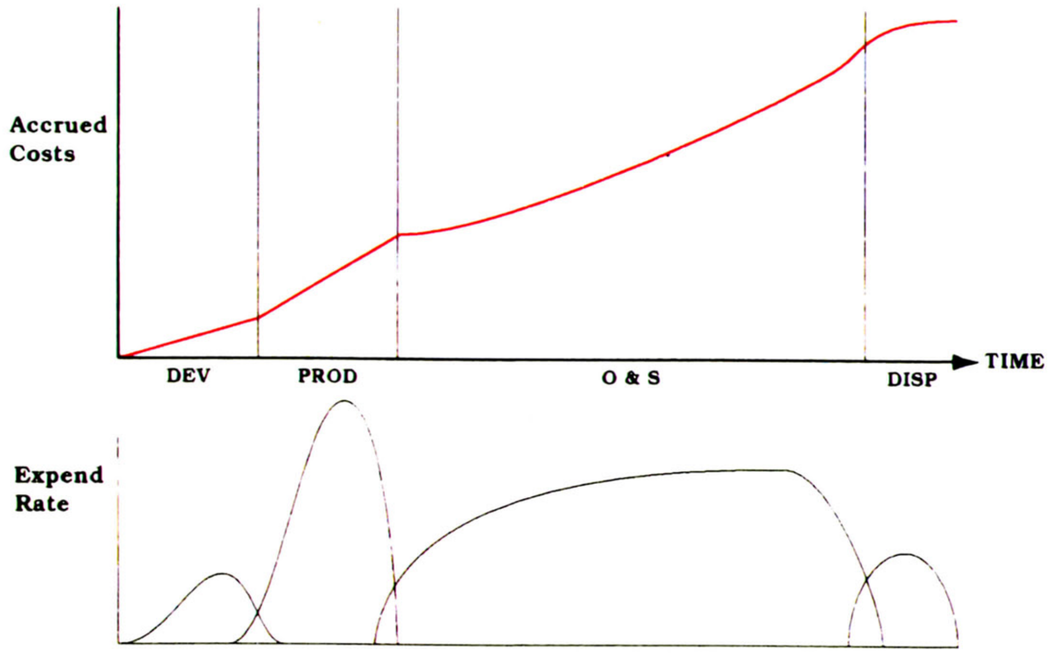
To meet the Navy goal of a 350-ship fleet by the year 2001, with an average ship life of 30 years, it is necessary to introduce approximately 12 new ships per year. Since 1990, the DON procurement budget has decreased by approximately 50%, while the O&S portion of the budget has remained almost constant (in constant FY 1996 Dollars--source: Navy Biennial Budget Highlights 1996/1997).

While 14 new ships will be introduced into the fleet in FY 1996, only six will be commissioned in FY 1997. Given the length of the procurement cycle for a ship, however, these levels reflect the much longer procurement budgets of five to eight years ago. More relevant to the present budget situation are the plans to approve construction of three new ships in FY 1996 and three in FY 1997. These planned procurements represent approximately 25% of the level required to maintain a 350-ship fleet. The Panel found similar, and in some cases, more dramatic, reductions in procurement levels for aircraft and missiles.

The end result yields a much smaller force structure than that required. Alternatively, less than required ship procurement levels, while keeping a constant fleet size, will result in older ships remaining in service. In addition, fleet size reductions exceeding that required to meet commitments will create operation tempo increases. The combination of increasing the operation tempo and age of the fleet will further exacerbate the O&S costs.

The incentive for DON to aggressively address LCC reduction is the need to increase the fraction of future DON budgets allocated to procurement of new weapons systems. Since the acquisition budget is already heavily managed and O&S costs constitute the largest share of today's DON budget, O&S costs represent the most fruitful source for LCC reductions.

Build Up of Life Cycle Costs

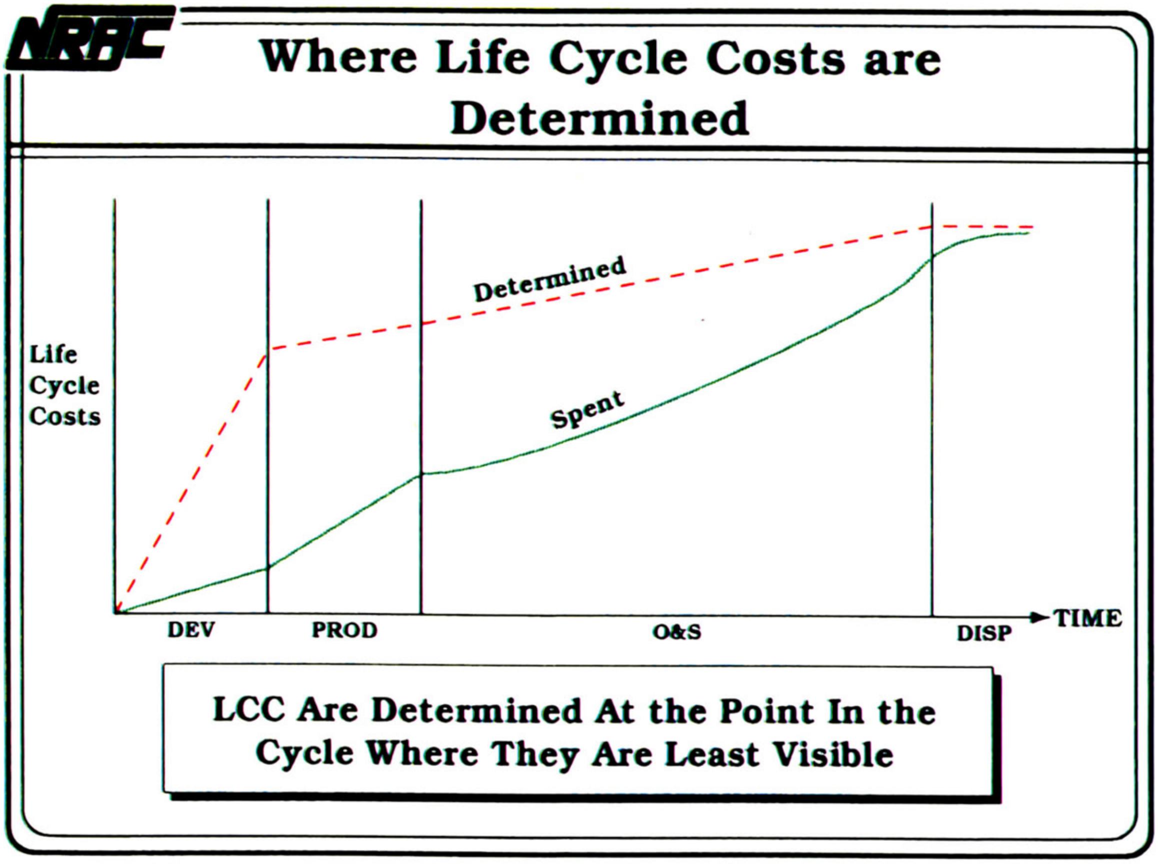


BUILD UP OF LIFE CYCLE COSTS

LCCs accumulate continuously, beginning with the development efforts associated with a new system and not becoming complete until the disposal of the last example of that system, as well as the related support infrastructure. Although LCCs accrue continuously, ownership and responsibility for those costs vary as the system passes through the development, production, operation, support and disposal funding pipelines. Throughout the life cycle of a system, the visibility is higher and the incentives are stronger to concentrate on near-term costs rather than longer-term costs.

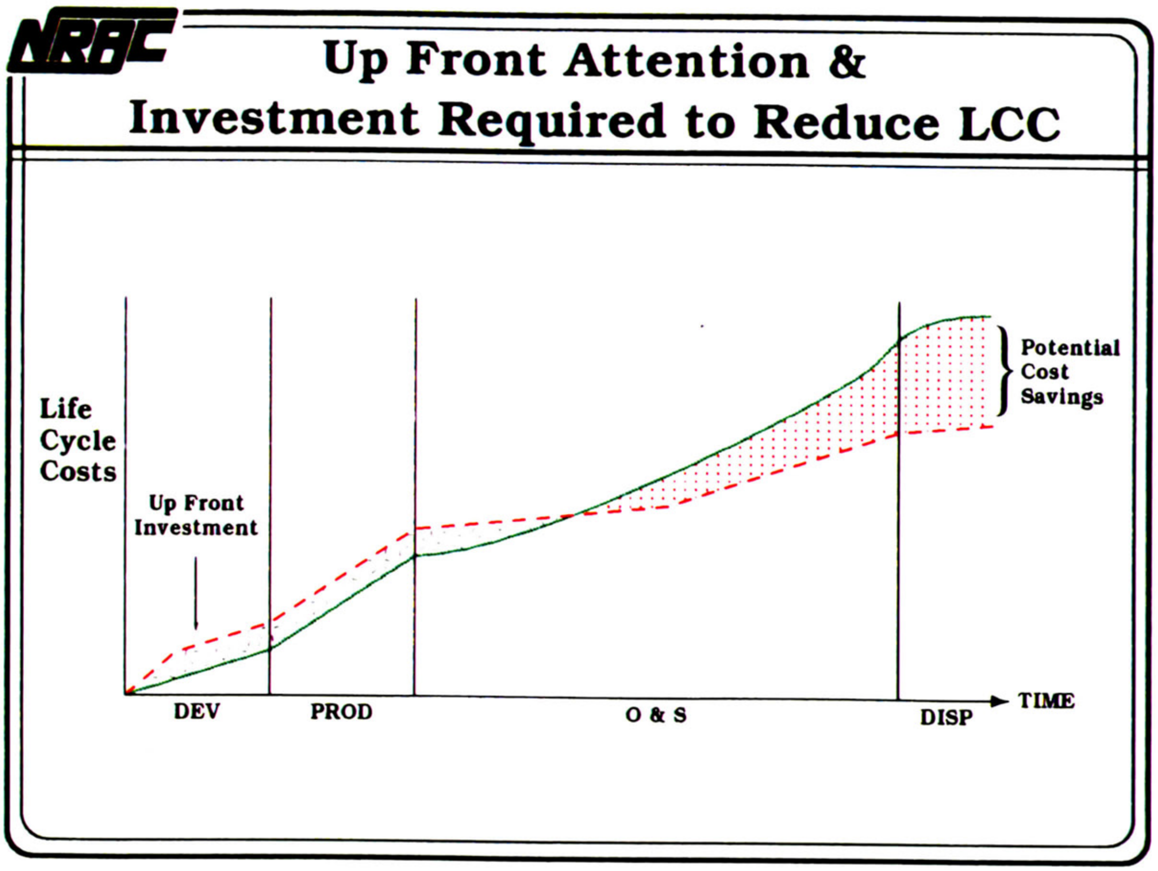
The total LCC of a system is not actually known until the end of a system's life. By that time, of course, nothing can be done to reduce those costs. At any point in the life of a system, two perspectives are useful: historic or sunk costs and future costs. Historic costs are readily available from a properly maintained database. They are useful in identifying LCC drivers and in predicting LCCs for similar or related systems. Historic LCC data are also essential for tracking and verifying the efficacy of LCC reduction initiatives.

Knowledge of future LCCs requires the ability to anticipate future LCC accruals. This can be done to some extent by making projections from historical data. This approach works best for reasonably mature technologies. The ability to project future LCC for systems dependent upon revolutionary technologies requires the ability to predict costs based upon process specific modeling and simulation. In order to intelligently select candidates for LCC reduction investment and to make engineering trade-offs among several design options, the ability to predict future LCC implications of various courses of action is essential.



WHERE LIFE CYCLE COSTS ARE DETERMINED

All costs incurred by the DON from the start of development through the end of production are generally described as acquisition costs. These, of course, include contractor costs as well as all associated costs that accrue internally to DON. By using competition among contractors, the DON generally does a good job of controlling costs during the acquisition phase. O&S costs required to sustain the system consist of both direct and indirect costs. The sum of these costs, combined with those costs associated with disposal, generally describe the system LCC. The costs experienced in each phase of the system's life are greatly affected by events that take place in the previous phases. This is especially true when considering the impact made on O&S costs by actions taken in the acquisition phase. Therefore, the actual rate of expenditure does not accurately reflect the rate at which LCCs are actually determined. Typically, 80% of the system LCCs are determined before production begins. In the worst cases, much of the LCC framework of a system may be unknowingly frozen during the requirements definition phase. Consequently, LCCs are largely determined at the point in the system's life cycle where they are least visible.

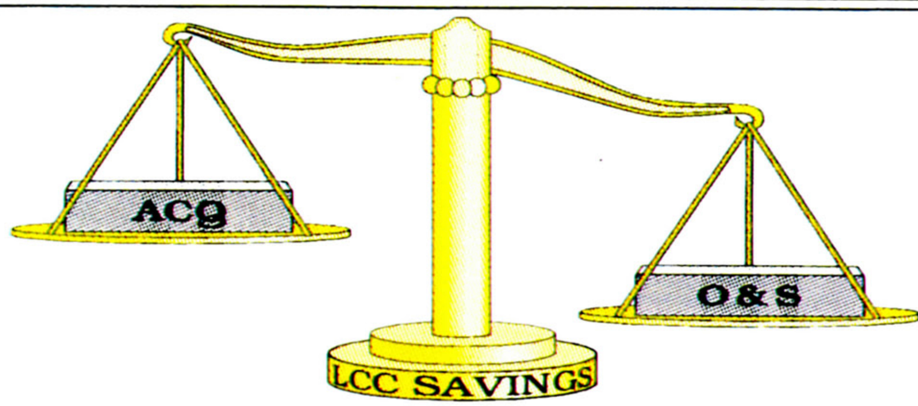


UP-FRONT ATTENTION & INVESTMENT REQUIRED
TO REDUCE LCC

Opportunities exist for LCC reduction at any time in a system's life. However, the return on the LCC reduction investment will be greatest when the investment is made early. It follows that since the majority of LCCs are fixed before production starts, the best time to give attention to, or invest in, LCC reduction is at the earliest possible stage of a system's life. This investment not only takes the form of capital, but intellectual effort as well. Ensuring that O&S issues are fully considered in the requirements definition phase, that financial investments in enabling science and technology are made in a timely way, or that alternative design solutions that offer longer term LCC savings are considered requires a carefully planned and executed LCC reduction strategy.

In order to establish where investments should be made, knowledge of historic LCCs is required to provide a baseline for prediction of future costs and to identify and highlight problems. Strong LCC prediction tools are also required to support this process.

Findings - LCC Reduction

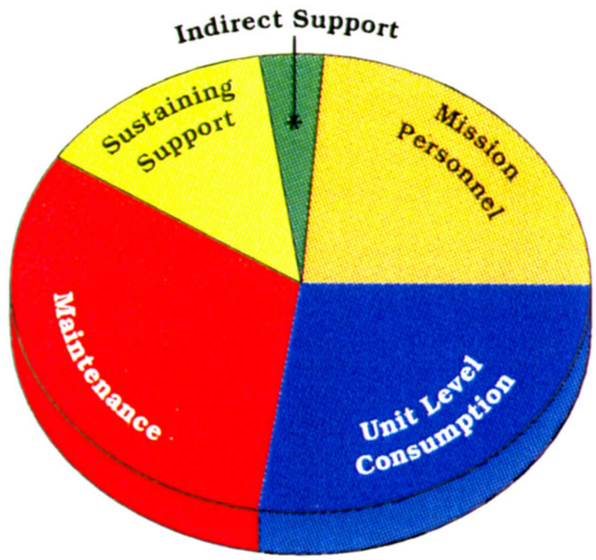


- **Unexploited cost savings in O&S**
- **O&S costs primarily influenced by acquisition process**
  - **S&T can solve part of the problem**
  - **Incentives for the buyer to consider the fiscal needs of the owner are also needed**

FINDINGS--LCC REDUCTION

O&S costs are the largest portion of the present DON budget and represent a largely unexploited source of potential LCC savings. Those O&S costs are largely determined during the early stages of the acquisition process when they are least visible. Properly directed investment in S&T can beneficially impact many LCC drivers once they are identified, but investment in S&T alone cannot achieve the broad and continuing O&S cost reductions necessary to alleviate the DON procurement budget problems. Cultural, organizational and policy changes are required to elevate O&S costs to the same level of visibility and consideration currently given to military performance and procurement costs during the acquisition phase, and to maintain that same level of visibility during the operational phase of a system's life.

Operational Systems



Notional O&S Distribution

OPERATIONAL SYSTEMS

Although the return on investment is less for operational systems, O&S costs dominate today's DON budget. Therefore, O&S costs of existing systems are thought to represent the greatest potential for near-term savings through LCC reduction initiatives. The opportunities for significant savings are limited primarily to personnel (the subject of a companion 1995 NRAC Summer Study), fuel and spares, and maintenance costs.

Although LCC problems for existing systems are typically more costly to fix, the benefits of LCC reduction initiatives are likely to be realized much sooner than for new systems.

An Existing System AN/SLQ-32

- **Problem:**
  - **Acquired based on performance & procurement cost with little regard for O&S cost**
- **Current Approach:**
  - **In-service engineering activity**
  - **Configuration management**
  - **Technical data package**

Correcting LCC Problems After Acquisition is Difficult and Costly

AN EXISTING SYSTEM--AN/SLQ-32

It is difficult to single out a single system representative of deficiencies in the DON's past acquisition practices with respect to downstream O&S costs. The success or failure of any program over its life cycle is highly dependent on many factors which are not readily generalized. Nevertheless, the AN/SLQ-32(V) Electronic Warfare System has exhibited several characteristics which might be considered typical of unplanned, mid-life O&S cost growth when LCCs are not adequately addressed in the acquisition phase.

The SLQ-32 system was developed in the mid-1970's to provide warning against the increasing threat due to anti-ship missiles. It was a "design to price" system, meaning that almost every aspect of the system was negotiable except the price. The prevailing wisdom at the time was that 90% of the cost of a system was incurred trying to achieve the last 10% increment in performance, so the SLQ-32 represented an attempt to control cost growth within a fixed contract ceiling. As such, excessive focus was placed on optimizing the performance while minimizing the unit cost of the system, often without regard for the impact on downstream O&S costs. The level of repair analysis conducted at the time was inadequate, resulting in an untenable two-level maintenance concept: it was presumed that the system would be maintained by the contractor, and no Navy in-service engineering was established. Also, no technical data package was included in the contract deliverables, and system subcomponents were procured largely from source control drawings. Making matters worse, electronic warfare at the time was characterized by rapidly changing threats so that program growth soon outstripped any attempt to maintain configuration management. Uncontrolled updates permitted hardware and software variants to proliferate, compounding the supportability problem.

By 1983, a combination of unacceptably low operational availability and concerns over system effectiveness led to a senior management review. In the years that followed, an In-Service Engineering Activity was assigned to Naval Surface Warfare Center (NSWC), Crane. System baselines and configuration management were established, as well as consolidation of depot-level repair activities and fleet support. Also, intermediate-level maintenance was instituted and technical data packages were generated, often by the tedious process of reverse engineering. Although the system is much improved today from a supportability standpoint, it continues to be plagued by unreliable components and diminishing manufacturing sources. The downstream costs associated with bringing this system under control have been enormous, but once a system as widely deployed as the SLQ-32 enters service, almost no other alternative exists than to fix the problems. The resulting unplanned O&S costs invariably come at the expense of modernization and new procurement. The SLQ-32 is an excellent example of how O&S costs are determined very early in the acquisition cycle by policy decisions, and that if not adequately addressed become increasingly costly to bear or reduce later on.

LCC Management of Existing Systems

- Fragmented
- Based on operational availability
- Little focus beyond IOC
- Investment required

LCC Management System Needed

LCC MANAGEMENT OF EXISTING SYSTEMS

The Panel found little evidence of effective, high-level emphasis on LCC management of existing systems across the DON. The DON has no comprehensive management system to reduce LCC for existing systems. Beneficial LCC reduction initiatives exist, but they are scattered and fragmented. Such initiatives typically arise when low reliability, sparse availability and other maintenance problems lead to unacceptably low operational availability. Otherwise, there is little emphasis on LCC reduction after Initial Operating Capability (IOC). The adverse impact of unplanned O&S costs on future procurement budgets must also be recognized and made visible.

In order to realize reductions in O&S costs that will significantly impact the DON budget, a comprehensive, DON-wide LCC management system is required.

Essential Characteristics of LCC Management

- **Mechanisms to identify cost drivers and predict results**
- **Investment strategy for reducing LCC**
- **Clarity of expectations & responsibilities at all levels**
- **Empowerment at appropriate levels**
- **Resources to implement cost actions**

ESSENTIAL CHARACTERISTICS OF LCC MANAGEMENT

The elements of O&S costs are extremely diverse, deriving from many budget categories. They are not easily aggregated, and their effective management presents a major challenge. However, the essential characteristics of a management system for reducing O&S costs are well known.

The first step is to establish a cost tracking mechanism capable of capturing complete LCCs in an accurate and timely way. This, of course, requires that all LCC elements be completely defined. The way in which certain items are accounted for in the DON, such as military personnel training and housing, is problematic in this regard. This cost tracking system must be capable of identifying O&S cost drivers at the system, subsystem and major component levels. The capability to predict LCC implications of corrective actions prior to implementation is also necessary to support an effective LCC reduction investment strategy.

Next, an LCC investment strategy must be developed to apportion available resources to appropriate LCC reduction initiatives. A vision statement is required to provide clarity of expectations and to assign responsibilities for reducing LCCs at all levels in the DON. In addition, empowerment of individuals to act at all appropriate levels within the DON is essential for success.

Finally, sufficient resources to implement and sustain significant and meaningful LCC reduction actions must be identified and provided.

Some Current O&S Reduction Initiatives

- **Team Hawk**
  - H-60 Helicopter
- **BOSS III**
  - Reliability and Maintenance
- **TIREP**
  - Obsolete Electronics
- **LM 2500**
  - Turbine MTBF

Supported by Existing Data Collection System (VAMOSC and various ILS databases)

SOME CURRENT O&S REDUCTION INITIATIVES

Examples of current O&S reduction efforts are depicted above. Each of these efforts has unique characteristics which provide the potential for significant LCC savings. These programs are representative of similar initiatives throughout the DON.

- TEAM HAWK is a joint service/industry effort to reduce O&S costs on the various H-60 helicopter programs, and to leverage limited service funding. A management working group was chartered in 1993 which has implemented efforts to reduce costs with initiatives such as joint contracting, common parts, joint parts management, interchangeability of subassemblies, anti-corrosion coatings, elastomeric rod ends for pitch links, etc. These initiatives have the potential for saving up to $180 million. The management structure of this project appears to be consistent with the Integrated Product Team (IPT) philosophy.

- The Best Overall Support Solutions (BOSS III) program is designed to reduce life cycle logistics support costs and improve readiness. This DON/industry effort focuses on lowering costs by (1) improving reliability/maintainability, and (2) modifying supporting infrastructures, including changes in maintenance philosophy. Investment of approximately $100 million in Logistic Engineering Change Programs has resulted in over $300 million in savings.

- A different type of effort to reduce cost is the Technology Independent Representation of Electronic Products (TIREP) program which is a tri-service initiative administered by the Office of Naval Research (ONR). The scope of this program is to produce a standardized process for redesigning and rapidly prototyping and producing equivalent form, fit, and function electronic assemblies. As electronic components in use become obsolete, this effort becomes essential for managing and reducing O&S costs as well as preserving operational availability of deployed systems. Its importance becomes even more critical as the service life of programs is extended beyond that originally planned. In cases where Technical Data Packages either do not exist or are incomplete or inaccurate, this capability is clearly important to O&S cost management and system supportability.

- The briefings received by the Panel on the LM 2500 gas turbine engine clearly showed how O&S costs can be reduced. For example, the Mean Time Between Failure (MTBF) has grown from about 1,400 hours MTBF at IOC to over 15,000 hours today! This program's manager outlined promising technology efforts to further reduce O&S costs if up-front investment is applied.

These programs are fed by existing Integrated Logistics Support (ILS) databases which can provide focus to areas where improvement may be achieved. With modifcation, the database known as Visibility and Accounting of Operations and Support Costs (VAMOSC) could become a more useful tool to support LCC reduction initiatives.

Visibility & Management of O&S Costs (VAMOSC)

- **Currently used to capture total cost of ownership**
- **Used for multiple customers for varying cost analyses (e.g. weapons systems cost estimates, force structure analyses, flying hour programs, etc...)**
- **Difficult to use for O&S cost reduction efforts:**
  - **Database:**
    - **Is at system level (vs. component)**
    - **Doesn't include all elements needed**
    - **Not user friendly**
    - **Not timely (data 1-2 yrs old)**
- **Strength: Existing, centralized database**
- **Developers aware of problems**

VISIBILITY AND ACCOUNTABILITY
OF O&S COSTS (VAMOSC)

In FY 1992, AIR and SHIPS cost data reporting systems were merged into Navy VAMOSC under the management of the Naval Center for Cost Analysis (NCA). Under Secretary of Defense Kaminski has recently advocated the use of VAMOSC by the acquisition community to determine and monitor O&S costs (memorandum of March 15, 1995).

VAMOSC ship data are currently used by CBO, GAO, COMNAVSURFLANT, COMNAVSURFPAC, OUSD(A), OASD(PA&E), NCA, CNA, DTRC, SYSCOMs and OPNAV for various analyses and cost reviews. NAVSEA utilizes VAMOSC ship data for major warship reviews and for CAIG reviews. ASN(RD&A) makes use of VAMOSC for milestone reviews, system trade-offs, and Cost and Operational Effectiveness Analyses (COEAs).

In order to develop and implement an effective LCC reduction program, certain shortcomings of the present VAMOSC must be corrected. It must be expanded to cover more systems than ships and aviation and to cover all significant platforms within all relevant categories. It must represent the total cost of ownership of systems, including training, non-weapon system support costs, depot operations, and environmental and disposal costs. In order to accurately represent the impact of various LCC reduction initiatives, DON must also define how infrastructure costs will be apportioned to LCCs of related systems.

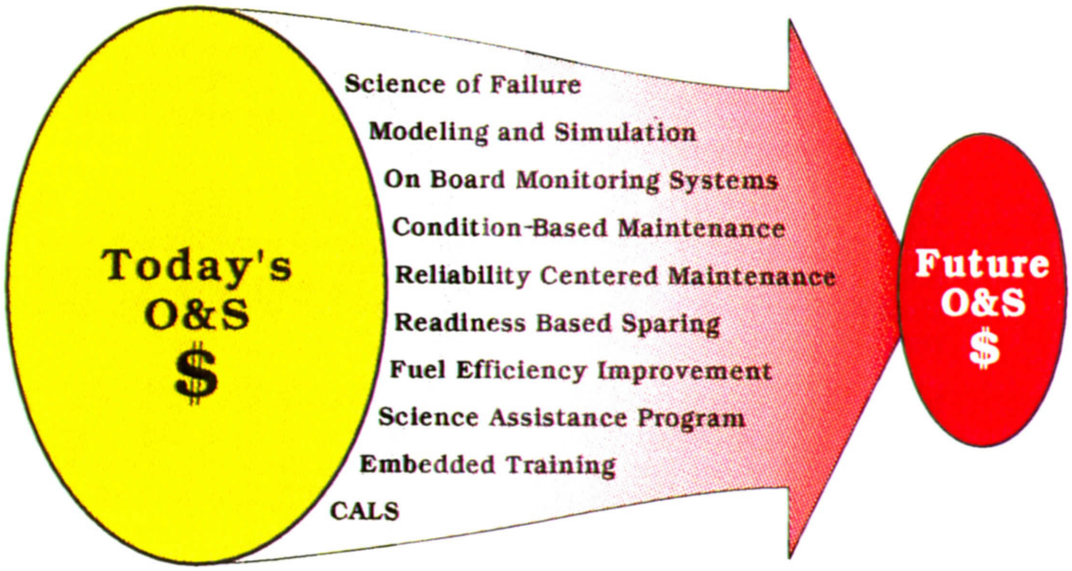
VAMOSC presently collects costs at the individual platform level. In order to identify cost drivers, especially when they may be common to several systems (air compressors, for example) it is important that costs be collected at the subsystem and major component level.

VAMOSC is presently constrained from imposing separate or additional reporting requirements. While this is an admirable attempt to reduce administrative burdens, it results in an 18- to 24-month lag in VAMOSC data. To be useful in identifying current cost drivers and assessing the effectiveness of LCC reduction initiatives, VAMOSC must be modified to make O&S cost data available in a timely way.

If VAMOSC is to be used to support an LCC reduction strategy, it must be readily accessible to a wide variety of DON users. In order to ensure the security and integrity of the data, it is likely that a series of templates will be required to allow appropriate access to various classes of users.

The strength of VAMOSC is that it is our existing, operational centralized data base containing a large amount of useful data. It is being used throughout a large segment of the DON today. It represents a significant investment, and there is no need to start over, but additional investment is required. The developers of NAVY-VAMOSC are aware of its shortcomings and stand ready to make the necessary improvement. They lack only the direction and resources to do so.

Potential for Reducing O&S Costs



POTENTIAL EXISTS FOR REDUCING O&S COSTS

The cost reduction initiatives discussed previously show that O&S costs can be reduced with management attention and resourcing. The chart above shows some of the innovations being applied or considered in various programs which have the potential for high payoff, if applied more broadly.

- Beyond the design of new systems, "science of failure" techniques to diagnose cause of component failures have the potential for improving reliability of such components. This technology can also be used to evaluate the applicability of less expensive commercial off-the-shelf (COTS) replacement components. Science of failure requires a first principles understanding of underlying phenomenology integrated with Modeling and Simulation of the process variables.

- On-board Monitoring Systems obviously have the potential for assisting in identifying pending failures and permitting appropriate action, as opposed to dealing with the resulting failure which can be much more costly. Not all system failures require such attention. Condition-Based Maintenance (CBM) and Reliability Centered Maintenance (RCM) techniques can reduce unnecessary maintenance, saving both manpower and spares cost.

- The use of Readiness Based Sparing (RBS) techniques for defining support packages has demonstrated much lower sparing costs. This classic inventory technique will produce spares packages optimized for a stated operational availability requirement or a fixed cost level. RBS is a powerful tool for reducing spares costs.

- Improving fuel efficiency will clearly lower operating costs. For example, briefings received on the LM 2500 indicated that additional S&T investment can provide very significant savings in fuel consumption (i.e., 30%).

- The Navy Science Assistance Program provides an ongoing opportunity to detect current operational problems and bring S&T attention to assist in solving the problems. The program should be used as one of the means for identifying O&S cost-reduction opportunities.

- Innovations to reduce training costs also have significant potential. For example, Boeing discovered that their mechanics use training routinely given on approximately 60% of repair items. They modified their training program appropriately to save training expense and manpower.

- Finally, the use of Computer Aided Acquisition and Logistics Support (CALS) has exciting potential for reducing cost and burden. Applications to replace hard copy paper documents with digital documentation have already resulted in tons of paper savings aboard ships with obvious cost savings.

Certainly many opportunities are available to reduce O&S costs for existing systems. These examples are intended merely to illustrate the possibilities available from disciplined application of such techniques across the DON for cost reduction.

Findings - Operational Systems

- **No DON process for reducing O&S costs**
- **Focused S&T initiatives can impact O&S costs**
- **Some O&S cost reduction initiatives are producing results**
- **Existing data collection systems are supporting these efforts**

For Significant Cost Reductions, Comprehensive Management of O&S Costs Across DON Is Required

FINDINGS -- OPERATIONAL SYSTEMS

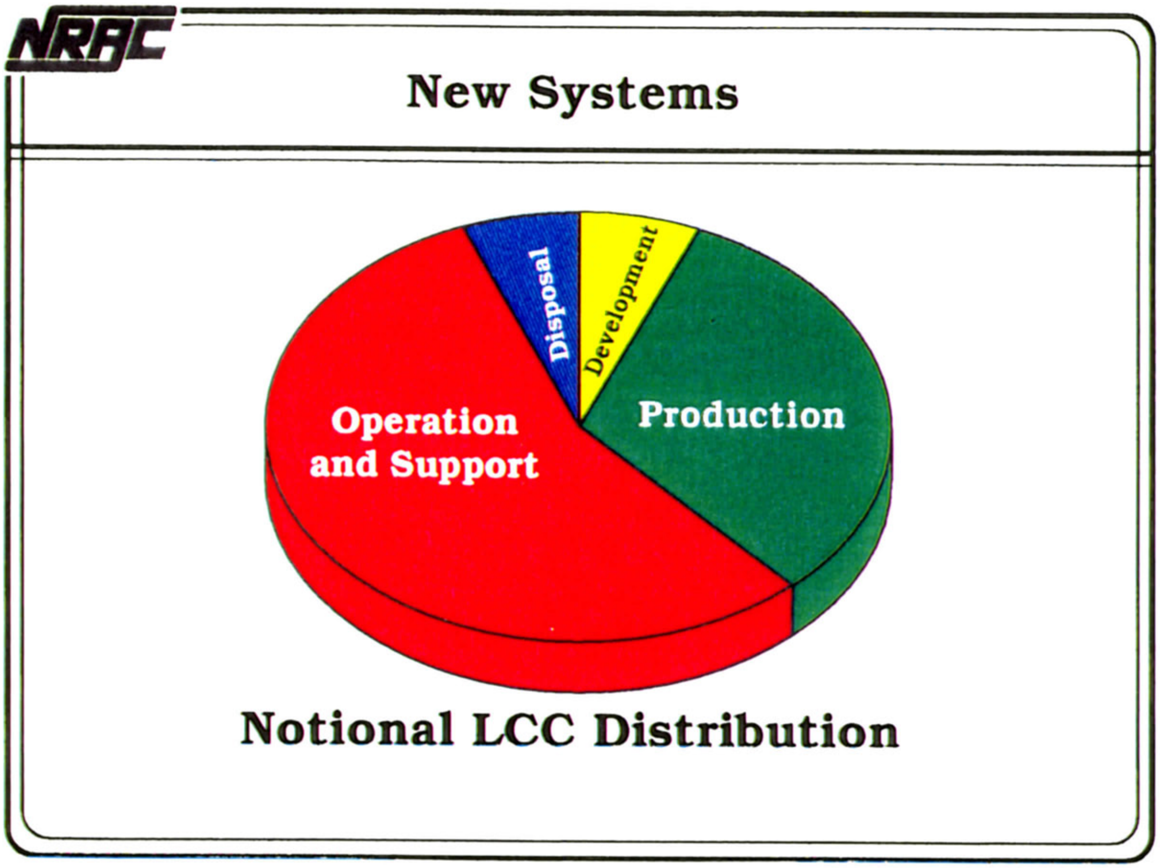
As indicated by VADM Earner and supported by Panel briefings, a disciplined, LCC reduction process is not in operation in the DON today. In view of the magnitude of the O&S budget relative to limited overall budget growth, an effective management approach that will bring about reductions in those O&S costs is required.

- Current techniques, including evolving science and technology-based tools, are available that can assist in bringing about significant LCC reductions.

- Some LCC reduction programs exist today which provide insights into how a comprehensive, Department-wide, disciplined system might work.

- The myriad of data collected currently need to be reviewed before a comprehensive architecture can be established to support the wide variety of users who are participants in managing O&S costs across the Navy. Potential exists for use of a modified VAMOSC system as a LCC reduction management tool.

Comprehensive, disciplined management of O&S costs must be implemented at all levels across the DON to obtain significant near-term benefits from O&S cost reduction.



NEW SYSTEMS

Since a broader range of design and operational alternatives exist with new systems, there is a much greater opportunity for LCC reduction for new systems. As noted earlier, historical evidence indicates that approximately 60% of LCC is attributable to O&S costs that can be influenced during the acquisition phase. In addition to significant opportunity for O&S cost reduction, the opportunity to influence acquisition costs is strengthened by LCC prediction capabilities. Overall, virtually all LCCs are subject to reduction by actions taken in the acquisition of new systems. It must be recognized that although the LCC reduction investments required for new systems may be smaller than for existing systems. the benefits will typically accrue over a longer period of time.

To better understand the potential for significant LCC reduction for new systems, the Panel reviewed initiatives in place to influence these costs, issues associated with O&S cost control, technical matters influencing LCC cost reduction. and opportunities on the horizon to impact LCC.

Current LCC Initiatives on New Systems

- **Major attention to performance and acquisition cost trade-offs**
- **Attention to O&S costs varies**
- **Useful prediction tools available**
- **Examples of best practice:**
  - **777**
  - **V-22**
  - **Comanche**

Key: Effective Use of Integrated Product Teams Requires Culture Change

CURRENT LCC INITIATIVES ON NEW SYSTEMS

In the early stages of new system development, major considerations are traditionally given to trade-offs between system performance (requirements) and acquisition costs. As it becomes increasingly more important to reduce costs, there are some individual program managers that are addressing O&S costs in the early stage of concept development. Consequently, the inclusion of O&S costs in these trade-off analyses is becoming more prevalent in the acquisition of both commercial and military systems. Attention to O&S costs presently varies with project leadership and program incentives. In general, however, the DON is not addressing this issue. Many tools are currently available that could be brought to bear on prediction of LCC. Actions within the S&T community, as well as in the broader acquisition community, are needed to bring these tools into a practical process of LCC prediction.

The development of the Boeing 777 represents the state-of-the-art best practice for the predicting of O&S costs throughout the design and development of a new system. Notable program initiatives briefed to the Panel which seek to control O&S costs by their early consideration in the acquisition process include the Navy's V-22 and the Army's Comanche programs. These efforts seek to reduce the traditionally high O&S costs associated with rotary wing aircraft.

The key enabler for including O&S cost considerations throughout the accquisition process is the effective use of IPTs. The IPT concept represents a relatively recent innovation in the accquision process. Here, a multi-disciplinary team is assembled under the leadership of the program manager to control all aspects of LCCs. To be effective in the DON, IPT membership must include appropriate experts from the Fleet, the systems command's functional support, and support facilities (e.g., depots), as well as representation from the training, and test and evaluation communities. Important to the success of IPTs is the provision of clear direction, with corresponding responsibility and accountability to team members, and empowerment to act.

Findings - New Systems

- **Although O&S cost determination begins during requirements phase, it does not generally play in trade-off decisions**
- **O&S cost consideration is a low priority compared to performance and acquisition costs**
- **Integrated Product Teams (IPTs) are effective in controlling O&S and disposal costs**
- **Contractor is an underutilized resource for O&S cost reduction during development**

FINDINGS--NEW SYSTEMS

Based on the Panel's review of new system acquisition programs, both military and civilian, insights were obtained that led to rationale for changes required to achieve reductions in LCC.

Abundant data exist that indicate O&S costs constitute the major portion of a system's LCC. This trend will continue as system life is extended due to budget constraints. However, due to the present acquisition and budget process, other elements such as development and production costs receive the most attention during the acquisition phase when O&S costs are being determined. Decisions are made during the definition of performance requirements phase that affect O&S costs in a major way. Since O&S costs are less visible and their implications are less immediate to the program manager, this element of LCC does not receive the attention that must be given if the DON is to control and reduce LCCs.

The Panel found that consistent characteristics among those new programs where significant attention is being given to O&S cost considerations are strong engineering, logistics, and customer inputs. These IPTs are credited with bringing the various management, technical, and customer viewpoints and disciplines together face-to-face to ensure proper consideration of all LCC elements, including O&S costs.

It is also noted that for new systems, as compared to existing systems, the contractor is a resource that can be used to advantage for reducing O&S costs, although not frequently employed to this end. Incentives must be provided for the contractor to focus on O&S cost reduction.

LCC Reduction Investment Strategy

- **Use Simulation Based Design (SBD) framework**
- **Identify cost drivers**
- **Predict LCC impact of possible actions**
- **Assess risk**
- **Select based on risk / ROI trade-off**
- **Implement selected decisions**
- **Develop tools as specifically required**

LIFE CYCLE COST REDUCTION
INVESTMENT STRATEGY

In order to effectively control LCCs, the DON must develop and implement a strategy to identify and invest in the most promising LCC reduction initiatives.

SBD methods and technology under development hold significant potential to improve performance predictions for new systems, and then provide a powerful new framework for making predictions that enable trade-offs to be made between LCC and system performance. Realistic prediction of LCC requires quantitative consideration of numerous cost drivers such as duty cycles, probability of failure for a broad spectrum of loads, mean time to failure under expected duty cycles, maintainability manpower and time required, level of repair analysis, and spare parts provisioning. Only with this capability can the effects of design and operational decisions on the resulting LCC be understood and trade-offs made.

While a great deal of historical data are available on selected aspects of LCC, additional detail is necessary to support both identification of drivers and credible prediction of LCC for evolutionary development of mature technologies. A new capability is required to realistically predict future LCC for revolutionary systems that are based on advanced technologies, beginning during the requirements definition phase and continuing throughout new system acquisition. Only with realistic prediction of LCC, as a factor in decision making during trade-off analysis, can LCC take a place comparable to that of system performance and procurement cost during acquisition. Availability of credible LCC predictions will provide a fundamentally new capability for DON consideration of investment strategies that hold the potential for major reductions in cost of ownership of new systems.

DON-developed risk assessment tools should be utilized in evaluation of investment options. Appropriate LCC reduction investments should be made based upon trade-offs between risk and investment required on one hand and predicted savings on the other. A system must be in place to implement these LCC reduction investment decisions which incorporates clearly stated expectations and responsibilities at all levels, as previously described.

Additional LCC tracking, prediction and management tools should then be developed as experience develops and particular needs arise.

LCC Reduction Non-S&T Requirements

- **Improve LCC tracking**
  - **Database**
  - **Completeness**
  - **Timeliness**
  - **Visibility**
- **Establish LCC prediction**
  - **Identification of cost drivers**
  - **Risk assessment methodology**
- **Provide incentives for contractor to reduce O&S costs**
- **Collect disposal cost database**

LCC REDUCTION--NON S&T REQUIREMENTS

The first step in taking action to reduce LCC is to make these costs visible. Much effort has been expended on the subject of predicting, cataloging, and tracking acquisition costs of systems. However, O&S funds for systems are spread across multiple appropriation accounts such as Operation and Maintenance, Navy (O&MN) and Military Personnel, Navy (MPN) and, in addition, are administered by diverse Navy organizations. If LCCs are to be properly managed, it is necessary to have an accurate and complete picture of O&S costs.

VAMOSC is an attempt to fill this need, but requires significant revamping and improvement. The following attributes are critical:

- Completeness--many cost elements are not presently captured.
- Timeliness--typically 1-2 years after the fact.
- Usability--database must be improved for access to satisfy customer's needs.
- Depth--database should extend below platform level to subsystem and/or major component levels in order to identify O&S cost drivers.

As a companion effort for improving VAMOSC, a capability is required to predict O&S costs, drawing on historical data for similar systems and using process-based models for more revolutionary systems. In addition to using such tools to identify potential cost drivers, it is important to quantify technical and programmatic risks of various alternatives. These predictive tools will be most useful to program managers for properly considering O&S costs during acquisition trade-off decisions.

The contractor(s) is presently an underutilized resource for reducing O&S costs of systems. Inevitably, the contractor is the most knowledgeable source of system details that can become O&S cost drivers. Present emphasis on minimizing procurement costs provides little or no incentives for contractors to take LCC reduction initiatives. Innovative contracting methods which provide contractor incentives for reducing LCC should be explored.

The costs associated with disposing of systems at the end of their useful lives are the most difficult element of LCC to predict. This is primarily due to the difficulty of anticipating environmental standards that will be in place at the time of disposal. Nonetheless, DON is presently expending large sums for disposal of obsolete or redundant systems. A serious effort should be made to collect these disposal cost data and extract whatever lessons may be useful to future programs.

LCC Reduction
S&T Opportunities

- **LCC Prediction**
  - **Manufacturing, maintenance and supply models**
  - **Failure prediction/Science of Failure**
  - **Integration of LCC prediction capability**
- **Operation Costs**
  - **Manpower reduction**
  - **Reduced fuel consumption/costs**
- **Support Costs**
  - **On-Board Monitoring**
  - **Non-destructive/non-invasive inspection**
  - **Repair of structural composites/metals**
  - **Corrosion/Erosion**
- **Disposal Costs**
  - **Environmentally friendly materials and processes**

LCC REDUCTION--S&T OPPORTUNITIES

Significant opportunities exist for S&T contributions to enhance LCC prediction. As indicated earlier, prediction of LCC requires in-depth modeling and analyses of numerous engineering and related technical drivers. The current capabilities used to predict manufacturing cost as a function of product and process alternatives, maintenance manpower and time drivers, cost and level of repair trade-offs, and supply requirements and costs need to be significantly advanced. Fundamental extensions of current failure prediction/science of failure analysis capabilities are required in order to provide rational input to the prediction of mean time to failure and assignment of associated reliability and maintainability factors. Finally, and most critically, advancements must be made in the current capability to integrate advanced LCC prediction capabilities with simulation based design and acquisition tools. Modern information science, technology and engineering analysis tools must be integrated with cost models to provide the needed LCC prediction capability.

Operation cost analysis is likewise needed to assess potential manpower reduction opportunities and limitations. Similarly, mission operation analysis must be linked with system performance models to predict fuel consumption and the associated costs.

Numerous technology advancements offer LCC reduction opportunities; e.g., advanced on-board condition monitoring devices, embedded training and diagnostic capabilities, and techniques and devices for non-destructive and non-invasive inspection. Extensions in related technologies supporting repair of structural composites/materials offer significant benefits during the O&S phase. Finally, the ever present problem of corrosion and erosion of materials in naval environments requires renewed S&T attention, with a focus on LCC reduction.

While predicting costs for disposal of systems after productive 20- to 30-year lives is extremely difficult, models are critically needed that can be used in assessing such costs as they relate to alternatives associated with environmentally adverse materials and processes.

LCC Reduction Study Conclusions

- **DON alternatives are:**
  - **Force Reduction or**
  - **Reduced Readiness**
- **Visibility of costs required**
- **LCC set early by acquisition decisions but O&S costs receive insufficient attention**
- **S&T investments are required, but can not solve the problem alone**
- **A change in the DON's will to control LCC required**
- **Investment strategy to support**

LCC REDUCTION STUDY CONCLUSIONS

The alternative to reducing LCCs of DON systems is some combination of reduction in force level and readiness. This, in turn, will require concomitant changes in US military strategy and global commitments.

In order to effectively manage LCCs, they must be made completely visible to all concerned parties in a timely way. This is particularly critical in the early stages of the acquisition process where LCCs are largely determined, but O&S costs, in particular, are least visible. It is critical that LCCs have the same degree of visibility in the requirements and acquisition processes as performance and procurement costs enjoy today.

Considered investment in S&T can contribute to LCC reduction for both existing and new systems. However, the ability and will to identify LCC drivers and predict the LCC effects of alternative design decisions are necessary in order to make effective use of S&T investment. Investment strategies and management systems for LCC reductions are missing and are critically needed in order to effectively implement DON policy on LCC reduction.

Recommendations - Develop & Support LCC Reduction Strategy

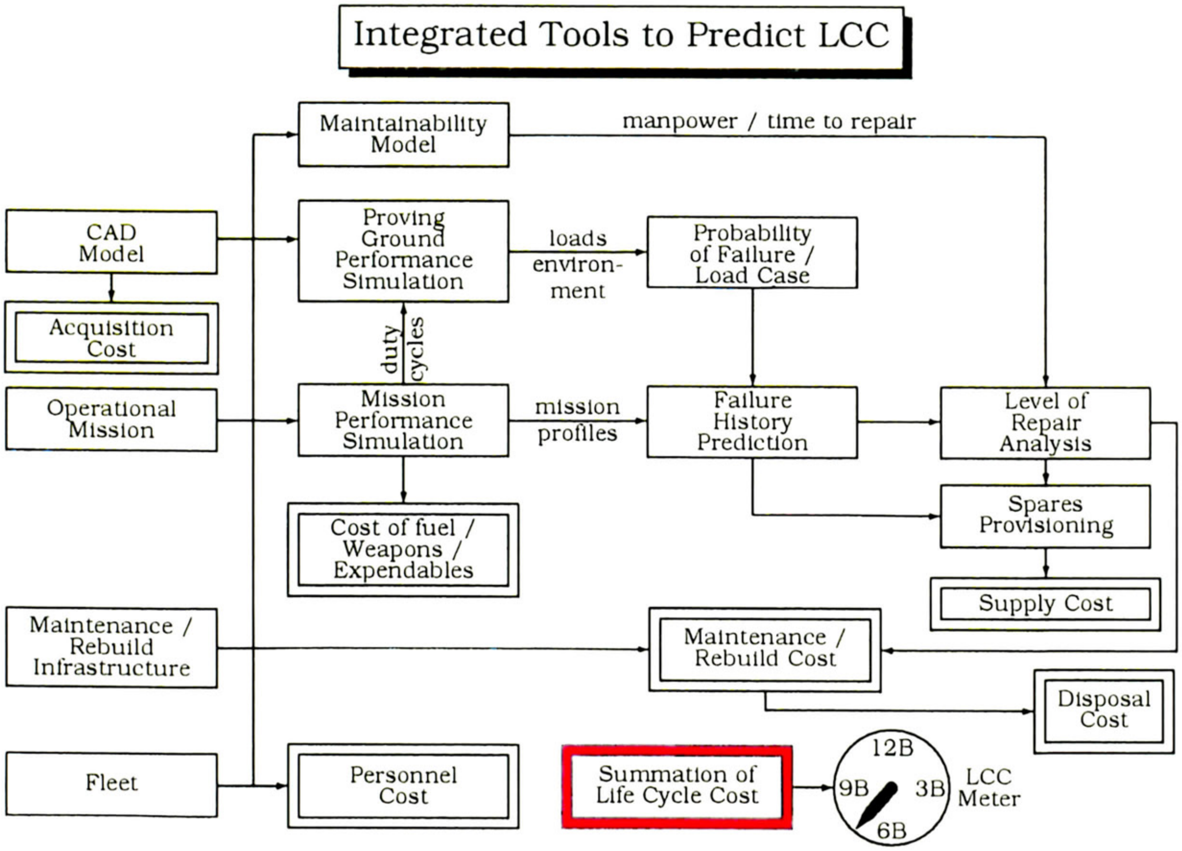
- **Make Life Cycle Costs visible**
  - Historic
  - Future
- **Develop and articulate strategy**
- **Align S&T investment to support**

RECOMMENDATIONS

DEVELOP AND SUPPORT LCC REDUCTION STRATEGY

Throughout the reviews conducted by this Panel, a common observation was the lack of visibility of life cycle costs, both historic and future. This is particularly true for O&S costs of systems. If LCCs are to be effectively managed, visibility of these costs is essential. Complete visibility of LCCs requires complete, timely and detailed historical data to identify cost drivers, as well as the ability to predict LCC implications of both evolutionary and revolutionary alternatives.

While numerous basic engineering and cost analysis tools are available to support LCC prediction, significant S&T and development effort are required to integrate tools into a software environment that is capable of supporting LCC reduction objectives of the DON. The diagram that follows is illustrative of the scope and connectivity of tools required to create a practical LCC prediction capability. An important aspect of this LCC prediction process is a regular review to compare actual costs to predicted costs and make appropriate adjustments to the prediction tools. It is also important to note that numerous basic engineering analysis and Computer Aided Design (CAD) tools are required to relate design, operation, support and disposal decision alternatives to the resulting LCC impact. The "LCC meter" shown at the lower right of the diagram is intended to communicate the LCC impact of alternative courses of action to the appropriate decision makers.



As the integrated LCC predictive tool set shown above is created and used in pilot projects, insights will be gained as to areas of weakness and high priority options for tool advancement to significantly enhance DON capabilities in LCC reduction. It is recommended that this feedback mechanism be used by S&T management to allocate resources to solve high priority problems and create high priority new capabilities. both based on practical experience gained in pilot projects by IPTs.

The DON must develop and implement a strategy to identify LCC drivers, predict the LCC implications of various alternative solutions, assess the risk associated with those alternatives, and select for investment those initiatives offering the most appropriate trade-offs between risk, investment, and cost reduction. This LCC reduction strategy must be clearly articulated, establishing expectations and responsibilities for all involved parties. Resources must be provided to implement the decisions resulting from application of this DON LCC reduction strategy.

Only when these two issues are addressed, visibility of LCC and an overall LCC reduction strategy, can a portion of the DON S&T investment be most effectively aligned to impact targeted LCC cost drivers.

Recommendations - Implement LCC Reduction Strategy

- **Select specific programs to demonstrate LCC reduction methodology**
- **Make effective use of IPTs with S&T and contractor representatives**

RECOMMENDATIONS--
<u>IMPLEMENT LCC REDUCTION STRATEGY</u>

As cultural change is implemented, based on a focus toward LCC reduction using IPTs, significant S&T effort will be required to create LCC prediction tools needed in all phases of the system life cycle. To guide LCC prediction tool development, it is imperative that actual system development projects be selected as pilots to focus research and development, and to provide a realistic proving ground for test and evaluation of the resulting tools and technologies. In order to be effective for their intended purpose, pilot projects selected should have the following attributes:

- They should be of appropriate size; e.g., a system having the level of complexity of a vehicle or a ship subsystem, in order to be both manageable in the context of S&T development and sufficiently complex to serve as a meaningful test of the tools and technologies developed.

- The systems selected should be in the concept development phase, so that a full spectrum of requirements definition, design, operation, support, and disposal options can be investigated as they impact LCC.

- The projects and associated systems should be amenable to use of simulation based design tools.

In parallel with S&T LCC prediction tool development, IPTs should be formed to implement LCC prediction and reduction methods in direct support of the pilot projects selected. These IPTs should include representatives from all organizations associated with the product being developed; i.e., requirements, development, production, and O&S. The Panel recommends including S&T representation from disciplines contributing directly to cost reduction goals and from S&T units that are creating LCC prediction tools and technologies. Care in forming these IPTs will be critical in assuring that LCC tools being developed are, in fact, focused on meeting real needs and at the same time fostering the cultural change required to achieve LCC reduction goals.

Since LCCs are being determined in the earliest phases of the acquisition process, it is important to find effective ways to include contractors or potential contractors on the IPTs. This will require careful attention to intellectual property issues but will ensure that contractors are knowledgeable regarding the LCC implications of design alternatives. The role of the contractor in reducing LCC should increase as designs mature, since contractors will necessarily be more deeply involved in design details than other IPT members.

It is essential that IPTs be implemented in more than name only. Team members must be empowered to assure their areas of responsibility receive due attention and must be held accountable for the elements of LCC under their responsibility.

Recommendations - Manage Life Cycle Cost

- **Commence control of O&S costs early in acquisition**
- **Provide incentives and resources for Program Managers to reduce O&S costs**
- **Provide clear CNO/CMC authority and responsibility for acquisition decisions affecting LCC**
  - **Military performance - CNO/CMC**
  - **Acquisition cost - Acquisition Executive**
  - **Life Cycle Costs - CNO/CMC**

RECOMMENDATIONS--
MANAGE LIFE CYCLE COSTS

Some of the new systems reviewed by the Panel, both commercial and military, stood out as good examples of LCC consciousness. These programs are characterized by strong engineering and logistics, leadership, and clear assignment of responsibility. Priority attention is being given early-on to operating, training, maintenance, logistics, and other O&S cost drivers. These characteristics are the same ones proven in successful, mature programs such as Nuclear Propulsion, Strategic Systems, and Aegis.

The Panel has concluded that S&T initiatives alone will not achieve the objective of controlling life cycle costs within the DON. Implementation of the S&T recommendations will make available modeling and design tools which permit the O&S portion of LCC to be considered on a par with development and production costs during system acquisition. The key to controlling LCCs in the long run is to properly consider O&S costs up-front in system acquisition, where a difference can be made. The decision makers (1) must have the tools to quantify O&S cost implications, (2) must have the incentive to properly weigh these implications, and (3) must have the resources and high level support to invest up-front if LCC savings are to be realized. These conditions do not uniformly exist today within the DON.

DON Program Managers, today, have clear responsibilities and incentives to maximize system performance and minimize procurement cost of systems under their direction. Thus, their resources are directed toward deriving maximum benefit from this procurement cost vs. performance trade-off. Merely providing them with tools to predict LCC implications of program decisions is not sufficient. Recognizing the increased uncertainty and less immediate impact of O&S costs, Program Managers must be provided with incentives to reduce O&S costs as well as resources to implement O&S cost reduction initiatives.

SECNAV Instruction 5400.15A addresses the need for life cycle management of the Navy's systems. Responsibility for managing in service support is assigned to PEOs/DRPMs and SYSCOM Commanders. As pointed out in this report, decisions made during acquisition can and do affect LCC in a major way. However, the CNO/CMC as the ultimate system and platform owner does not have sufficient authority and responsibility for acquisition decisions affecting O&S costs.

The Panel recommends that, to achieve the attitude change required for early consideration of LCC, the CNO/CMC be given authority to participate directly in acquisition decisions affecting LCC as is now done for decisions affecting military performance. PEOs/DRPMs and SYSCOM Commanders should report to the CNO/CMC as well as the ASN(RD&A) for acquisition matters in this regard.

Appendix A: Detailed Briefings/Visits

Title	Briefer
Agenda for visit to CINCLANTFLT (Maintenance), Norfolk, VA:	
<u>16 May 95</u>	
Panel Chair Welcome	Prof. Bill Weldon, Panel Chair
ASN(RD&A) Sponsor Greeting	VADM W. A. Earner, Jr., USN
Simulation Based Design Advanced (SC-21)	Mr. Gary Jones,
WSQMB Life Cycle Cost	CAPT Bill Cobb, USN
Life Cycle Costs - NAVAIR	CAPT Hammonds, USN and RADM William J. Tinston, Jr., USN,
Life Cycle Costs AAA/V	COL Feigley, USMC
<u>17 May 95</u>	
Surface Combatant 21	CAPT Denny Mahoney, USN
VAMOSC Model	CDR Mickler, USN
Life Cycle Cost of Weapons 017	Mr. Mike Hammes, NAVSEA
Life Cycle Cost - OSD	Mr. Jeff Jones, USD(A&T)
Cost Analysis Improvement	Dr. David McNichol, CAIG
Life Cycle Costs - NAVSUP	Ms. Karen Meloy
<u>18 May 95</u>	
CINCLANTFLT Regional Maintenance Office	Mr. Fred Lutz
CINCLANTFLT Maintenance	Mr. David Starkson
CINCLANTFLT Maintenance	RADM Vernon E. Clark, USN
Condition Based Maintenance	CDR Pete Sisa, USN
<u>19 May 95</u>	
Tour Norfolk Naval Shipyard	
CVN Program Overview	CAPT Perkins, USN
NNS Product Modeling Capabilities and ILS	Mr. Mike Powell
Production Process Upgrades	Mr. Scott Stabler
Shipyard Tour	Mr. Bill Ward
	Mr. Mike Petters and CAPT Perkins, USN
• 1300 - SPF	Mr. Bill Ward
• 1320 - Shipway 12	Mr. Jim Morris
• 1400 - Tour of Shipyard Facilities	
• 1415 - Tour of USS John C. Stennis	Mr. Miff Miffleton

Title	Briefer
Agenda for Tour of Boeing Aircraft Facilities, Seattle, WA:	
6 June 95	
Boeing Representative Welcome	Ms. Karoline Seely
Brief on Simulation Based Design	Military Systems Division
Tour Simulation Based Design Facilities	
Brief on Life Cycle Cost Estimating	
Brief Engineering for Reduced Maintenance	
Update on Engineering for Reduced Operating and Maintenance Costs	
Tour of Everett Production Facility and 777	
7 June 95	
Tour United Airlines Maintenance Facility, San Diego, CA	
Round Table Discussion	Ms. Peggy Dido, Fleet Engineering
Walk through United Airlines Maintenance Facility	
Agenda for meeting at ONR Arlington, VA:	
20 June 95	
Requirements Process and Life Cycle Costs	OPNAV N81
ASN(RD&A)	Mr. Doug Patterson
Joint Advanced Strike Technology - Life Cycle Costs Tradeoffs	
Center for Naval Analyses	
COEA Process NAS, AAA/V)	
Weapons System Cost Reductions	Air Force Materiel
ONR - TIREP	Mr. Ingham Marker
LM2500 Program and LM2500 Follow-on	PEO Aegis
DDG-51 vs Japanese Aegis	PEO Aegis
Board of Inspection and Survey (SLQ-32, LM2500, SPRUANCE)	LCDR Ron Elliott, USN
LPD-17- Designing for Life Cycle Cost	NAVSEA
Comanche Life Cycle Cost Decisions	Army
EDCAS, Level of Repair	Lockheed Martin
Condition Based Maintenance	NAVSEA 03
Life Cycle Cost of Trident	Strategic Systems Programs Office
Life Cycle Costs	Royal Navy

Appendix B: Glossary of Terms

AAA	Advanced Amphibious Assault
AN/SLQ-32	Electronic Warfare System
ARL	Applied Research Laboratory
ARPA	Advanced Research Projects Agency
ASN	Assistant Secretary of the Navy
ASN(RD&A)	Assistant Secretary of the Navy (Research Development and Acquisition)
BOSS III	Best Overall Support Solutions
CAD	Computer Aided Design
CAIG	Cost Analysis Improvement Group
CALS	Computer Aided Acquisitions and Logistics Support
CAPT	Captain, US Navy
CBM	Condition Based Maintenance
CBO	Congressional Budget Office
CEO	Chief Executive Officer
CINCLANTFLT	Commander in Chief Atlantic Fleet
CMC	Commandant of the Marine Corps
CNA	Center for Naval Analyses
CNO	Chief of Naval Operations
COEA	Cost and Operational Effectiveness Analyses
COMNAVSURFLANT	Commander Naval Surface Force Atlantic
COMNAVSURFPAC	Commander Naval Surface Force Pacific
COTS	Commercial off-the-Shelf
CVN	Nuclear Aircraft Carrier
DCNO	Deputy Chief of Naval Operations

DOD	Department of Defense
DON	Department of the Navy
DRPM	Direct Reporting Program Manager
DRPM(AAA)	Direct Reporting Program Manager (Advanced Amphibious Assault)
DTRC	David Taylor Research Center
EDCAS	Equipment Designer Cost Analysis System
GAO	Government Accounting Office
ILS	Integrated Logistics Support
IOC	Initial Operational Capability
IPT	Integrated Product Team
JAST	Joint Advanced Strike Technology
LCC	Life Cycle Cost
LCDR	Lieutenant Commander, US Navy
MPN	Military Personnel, Navy
MTBF	Mean Time Between Failure
NAVAIR	Naval Air Systems Command
NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NCA	Naval Center for Cost Analysis
NNS	Newport News Shipyard
NRAC	Naval Research Advisory Committee
NSWC	Naval Surface Warfare Command
O&MN	Operation and Maintenance, Navy
O&S	Operations and Support
OASD(PA&E)	Office of the Assistant Secretary of Defense (Program Analysis and Evaluation)
ONR	Office of Naval Research

OPNAV	Office of the Chief of Naval Operations
OSD	Office of the Secretary of Defense
OUSD(A)	Office of the Under Secretary of Defense (Acquisition)
PEO	Program Executive Officer
PEO(JAST) Strike	Program Executive Officer (Joint Advanced Technology)
RBS	Readiness Based Sparing
RCM	Reliability Centered Maintenance
ROI	Return on Investment
S&T	Science and Technology
SBD	Simulation Based Design
SECNAV	Secretary of the Navy
SPF	Shipyard Production Facility
SSPO	Stategic Systems Programs Office
SYSCOMS	Systems Commands
TIREP	Technology Independent Representation of Electronic Products
UK	United Kingdom
USD	Under Secretary of Defense
USD(PA&E)	Under Secretary of Defense (Program Analysis and Evaluation)
VADM, USN (Ret.)	Vice Admiral, US Navy (Retired)
VAMOSC	Visibility and Accounting of Operations and Support Costs
WSQMB	Weapon System Quality Management Board