A LIFE CYCLE COST APPROACH FOR MILITARY AVIATION.

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Abstract.

Organizations, users and managers need to make decisions on the acquisition and ongoing use of many different assets. The initial capital outlay is usually clearly defined and is often a key factor influencing the choice between alternative assets. There are, however, other future costs that should also be considered if the best outcome is to be achieved. The process of identifying and documenting all the costs involved over the life of an asset is known as life-cycle costing (LCC).

Future costs associated with the use and ownership of an asset are often greater than the initial Acquisition cost that can vary significantly between alternative solutions. This is a major concern of the HAF, especially the latest years due to the economical crisis of the country, in order to fulfill the operational requirements. HAI as well providing MRO (Maintenance, Repair and Overhaul) services to the majority of various weapon systems, is the main in country Defense Industry responsible for their Sustainment.

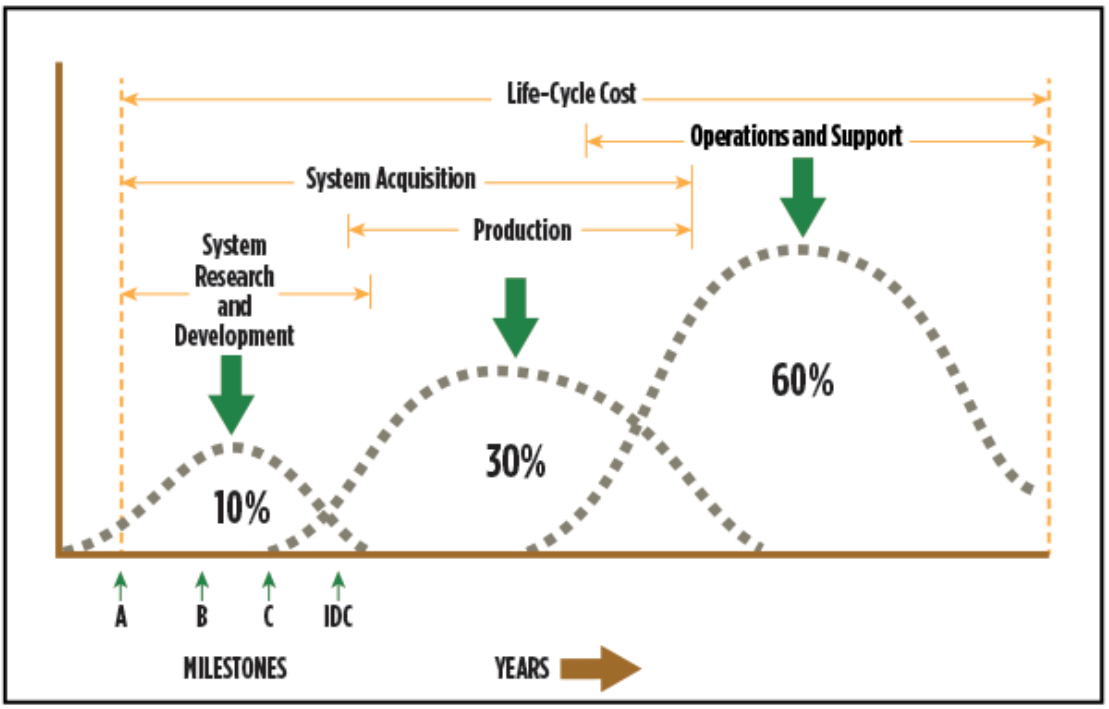
The best opportunities to achieve significant cost benefits occur during the early concept development and design phase of any project. The concept of the life cycle of an asset provides a framework to document and compare alternatives.

A good knowledge of the actual operating costs of an in-service asset is important not only for improving the cost-effectiveness of the asset in question, but also to improve the specifications of future assets.

Having a comprehensive and readily useable data base of life-cycle costs, enables decisions on changes to the asset and revisions to maintenance policy to be made with the assurance that the cost implications of these changes are well founded. Further, the ability to identify those components and features generating high costs in systems currently in use, can help to drive improvements that lead to cost reductions, and enable better budgeting for future expenditure.

Life Cycle Cost (LCC)

LCC as shown in the chart, is typically divided into three phases:



• **Research and Development** costs start with program initiation at the Conceptual phase through the end of engineering and manufacturing development. R&D includes costs for feasibility studies, modeling, trade off analyses, engineering design, development, fabrication, assembly and test of prototype hardware and software, system test and evaluation, developing support equipment, and documentation

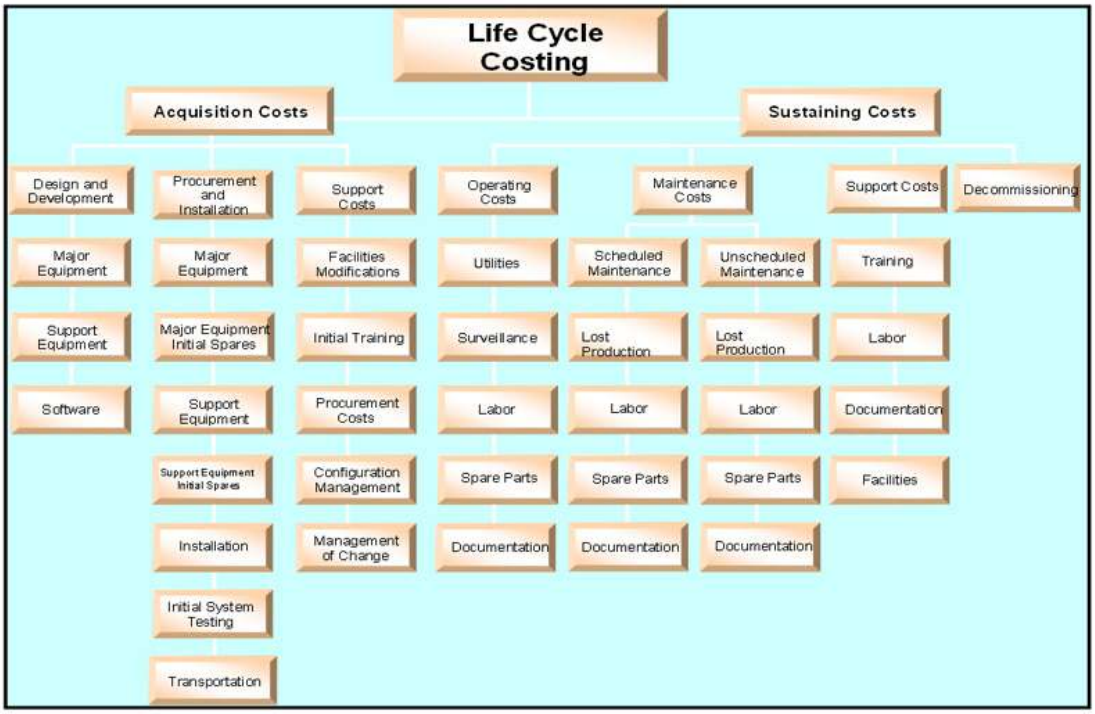
• **Production or Procurement** includes costs associated with producing or procuring the physical parts of the system, and costs associated with initial logistic support requirements (i.e., support equipment, training, data, initial spares, and facilities)

• **Operation and support** costs are incurred when systems are deployed and fielded. They include costs of sustaining operation, personnel and maintenance, consumable and repairable parts, and system modification.

Another cost that usually we are not taking into account is **Retirement and Phase-out** costs, which are associated with deactivating or disposing of a materiel system at the end of its useful life. Disposing of a materiel system can result in additional costs or a salvage value. These costs are normally insignificant compared to the total LCC.

Certainly, several aspects of Total Operation Cost (TOC) are not controlled or even influenced by acquisition managers. For that reason, program cost estimations are normally focused on life cycle cost or its elements. Situations where cost estimations support the acquisition system include affordability assessments, analysis of alternatives and cost performance.

A most analytical Diagram of the LCC is presented in the following illustration.



Operation and Support Cost (O&S)

Maintaining military aircraft in a high state of readiness requires a non-stop flow of spare parts. When parts must be removed, there are two primary sources for the replacement parts: new parts from procurement or repaired parts coming from overhaul. The costs associated with the acquisition, overhaul, transportation and labor to remove and install these parts are a significant part of a system's total Operations & Support (O&S) costs.

Moreover, these O&S costs generally account for 70% to 80% of total lifecycle costs, and, as a result, much attention has been directed recently towards the reduction of O&S costs in Defense budgets.

One important approach for reducing O&S costs is to improve reliability. A part with higher reliability is replaced less often, thus, reducing maintenance labor and the required flow of new and repaired replacement parts. This reduction in the on-going supply of replacement parts potentially, but not necessarily, reduces O&S costs. The overall cost impact depends upon any increase in the cost of the new improved part, the increase in reliability, the demand level and whether older parts can be transformed to the new more reliable design through overhaul.

Even if costs are reduced, it may not be a sound business decision depending upon the required investment. Business case analyses must answer the questions: **"What are the reductions in lifecycle costs arising from an investment in reliability improvement and what are the return and**

payback time for the required investment and what role does overhaul play in determining lifecycle returns?"

All possible scenarios reported have shown that improvements in reliability can greatly reduce the total costs. However, it is noted that the possibility for cost reductions cannot continue to increase forever. Diminishing returns exist as the investment amount grows past a certain amount. If the investment amount is too substantial in size, costs savings can still be achieved but not in the most efficient form.

O&S costs may be greatly decreased in size, but excessive investment and production costs will counteract the main goal of reducing total lifecycle costs. The returns are so substantial because twenty year lifecycle spent reductions are very large, ranging from $700 to $900 million **for a single part** that costs $250,000. These results dramatically illustrate the benefits that are possible by improving reliability and the important role that overhaul plays in achieving these benefits.

The increasing cost of operating and supporting weapon systems is a growing concern, because these escalating costs reduce funds available to develop and acquire new weapon systems and modify existing ones.

O&S costs include those for fuel, repair parts, maintenance, and contract services, as well as the costs of all civilian and military personnel associated with a weapon system. History indicates that these costs can account for about 70 percent of a system's total life-cycle costs.

LCC- USAF Experiences and Lessons learned.

The last decade of the 20th century US Government phased funding problems to fulfill its defensive operational requirements. Specifically in 1999, the USAF spent more than $16 billions to operate and support its aircraft. To help control operating and support costs, the Department of Defense (DOD) had set cost reduction goals for each military service, both for fielded weapon systems and for those being developed.

A series of reports were published, in order to evaluate DOD's efforts to reduce operating and support costs, especially focused on the Air Force's aircraft.

To help reduce the operating and support costs of fielded systems, the USAF had established several initiatives, including the Reduction in Total Ownership Cost program. Under this program, the Air Force developed a standardized methodology for assessing operating and support costs, identifying likely areas for cost reduction, proposing cost reduction projects, and tracking associated savings. However, the projected cost reductions from these efforts averaged only about $343 million each year, well short of the $2.6 billion to $7 billion needed to achieve DOD's goals.

Several factors hinder greater operating and support cost reductions. The USAF did not give O&S cost management the same high priority it assigned to other program concerns such as weapon performance during system development or improved combat capability after fielding.

Instead of establishing an O&S cost requirement and managing to meet it, new programs focused on initiatives to improve reliability, supportability, and maintainability. Although these initiatives did help lower operating costs, their impact on a system's operating and support costs was not tracked**.**

Projects that could have lowered these costs in fielded systems could not compete effectively for funding against projects that enhance safety, readiness, or combat capability**.** Because they were not given the same management priority, operating and support costs were not emphasized. Poor visibility of O&S costs had been a key factor inhibiting management of operating costs, moreover the establishment of the new Air Force Total Ownership Cost data system appeared to be overcoming this barrier.

The Under Secretary of Defense for Acquisition, Technology, and Logistics had expressed concern that rising operating costs threatened the Department's modernization efforts. In 1998, he observed:

"Unfortunately, we are trapped in a `death spiral.' The requirement to maintain our aging equipment is costing us much more each year: in repair costs, down time, and maintenance tempo. But we must keep this equipment in repair to maintain readiness. It drains our resources--resources we should be applying to modernization of the traditional systems and development and deployment of the new systems. So, we stretch out our replacement schedules to ridiculous lengths and reduce the quantities of the new equipment we purchase & minus; raising their costs and still further delaying modernization."

According to program managers, repair parts are the top candidates for cost reductions because new and more reliable parts and processes can be designed and manufactured to replace parts that fail often or are difficult to obtain. More reliable parts fail less often and require less maintenance.
For example, replacing all USAF F-16 fleet, main aircraft battery with a maintenance-free battery was expected to cost $3.4 million and save $3.8 million over the next 9 years and $6.9 million over the next 25 years.

There are some critical parts on each system, especially parts associated with engines and electronic subsystems that dominate the maintenance and repair costs of the aircraft. For example, the F-16 fighter has nearly 7,000 repairable parts. Of these, the 25 most fault-prone parts cost $224 million to repair in fiscal year 1998 and accounted for about 44% of the system's total repair parts cost. Sixteen of these 25 parts were for the aircraft engine, while another 4 were for the radar system.

As of February 2000, the USAF had approved 43 cost reduction projects that used the Reduction in Total Ownership Cost approach and were either under

way or planned for 8 fielded aircraft over the next several years. Between fiscal year 2000 and 2009, the Air Force planned to invest $7.9 billion in these projects. Annual average savings over the next 10 years were expected to reach $343 million. The Reduction in Total Ownership Cost Program Manager reported that savings for many projects were realized slowly because, once they were approved and funded, it would take several years to design, test, and produce the new part or process and install it in all the affected aircraft. Once installed, however, many projects realized savings over the aircraft's remaining useful life, which can be 20 years or more. By 2009, the Air Force expected savings and avoided costs to exceed $3.4 billion.

The examination of the 43 proposed projects for fielded aircraft showed that some of them, particularly those having the largest investments, are intended principally to provide readiness and performance improvements.

While these initiatives did help lower operating costs, their impact on the system's operating and support costs was not tracked. Projects that could lower operating and support costs were unable to compete effectively for funding against projects that enhance safety or readiness or improve combat capability.

Poor visibility of operating and support costs has been a key factor inhibiting management of operating costs, but the establishment of the new Air Force Total Ownership Cost data system appeared to be overcoming this barrier. Although program managers of pilot programs had been given greater responsibility for weapon system support, they reported that limited authority and few incentives are major obstacles to managing operating costs.

It is becoming obvious that setting performance requirements early in an acquisition program, without adequate knowledge of the total cost can lead to very costly and unstable system designs because the new programs do not have comparable operating and support cost requirements.

Further, they are not required to determine and justify the consequences of design decisions that are based on the system's projected operating and support costs. Without such a requirement, there is no accountability for minimizing the systems' operating and support costs.

Unknown Effects on O&S Costs

The developmental programs under examination do not have O&S cost requirements for the total system, but they generally have efforts underway to improve supportability, reliability, and maintainability.

Improving these characteristics, O&S costs can be lowered. For example, development of a system that can diagnose and predict engine problems in the Joint Strike Fighter before they develop is expected to reduce significantly, engine maintenance and downtime. In essence, a system component that is easier to access, remove, and replace costs less to maintain. Similarly, a more reliable component requires less maintenance and repair.

Projects that could reduce O&S costs of fielded systems have a lower priority and are generally less able to compete for investment funds than those offering improved safety, readiness, or combat capability for two reasons:

First, most cost reduction initiatives require up-front investments of procurement funds that take many years to pay back the initial investments. This slow pay-back, and the many uncertainties that accompany improvement projects, make it difficult for the initiatives to compete against investments that provide near-term improvements in safety, availability, or combat capability.

Second, the Air Force sees improved combat capability as the most important priority. Decision makers', whether in program offices, major commands, product centers, or air bases, principal focus is to improve combat capability. They work continuously to enhance system safety, increase readiness, and improve performance. While they acknowledge the importance of managing operating and support costs and recognize that growth of these costs may threaten the Air Force's ability to modernize, the near-term combat capability is their top priority.

Cost Management

Accurate and complete cost data and estimations are important for cost management because they often serve as the basis for establishing cost requirements that guide design choices and other trade-offs during development. Similarly, reliable cost data is necessary for managers of fielded aircraft to guide investment and system management decisions.

Air Force program managers have limited visibility over a system's O&S costs. Control over the essential resources and processes that determine how these functions are managed, however, remain largely with the major commands and headquarters organizations. O&S costs for a system are largely determined when an aircraft is designed. Once a system is fielded, a program manager of a system such as the F-16, for example, can directly influence no more than about 14-17 % of the system's O&S costs.

Program managers can influence the cost of maintenance by acquiring a more reliable part or revising a maintenance procedure, but they cannot control when or how often a system is used. They cannot decide the number of pilots or support personnel that are needed, the number of hours a system is to be used, or major maintenance schedules. Thus, significant personnel, base operations, maintenance, and overhead costs are outside their control or influence.

Similarly, program managers do not manage or control the funds used to pay for operations and support functions and activities or the investment funds used to make cost reduction improvements. Authority for managing operating and support funds, as well as aircraft improvement funds, again rests with the major commands and Air Force headquarters.

Also, the major commands or Air Force headquarters routinely deduct the estimated savings from programs' future budgets before the savings are actually realized. If a cost reduction initiative does not go as planned or does not achieve the estimated savings, the program must make up for the insufficient investment or unrealized savings.

The absence of clear, well understood, and frequently reported operating and support cost requirements for new systems undermines effective cost management during the critical design phase, when most future O&S costs are determined. Similarly, the absence of an O&S cost requirement for fielded systems precludes management attention and inhibits investments in cost reduction projects needed to meet DOD's goals.

Accordingly, **it is unclear what maximum acceptable O&S costs the Air Force is willing to pay during a system's life**; therefore, there is no way of knowing whether sustainment expenses or projected costs are reasonable. Ultimately, because there is no accountability for operating and support costs of aircraft programs, oversight and management remain difficult.

To establish accountability for reaching DOD's goals of significant O&S cost reductions, the Air Force needs to establish O&S cost requirements for the aircraft it is developing or procuring and for those that are already in service.

DOD has to establish an O&S cost requirement for developmental and fielded weapon systems to ensure full consideration of these costs among other program priorities and measure and periodically assess progress toward meeting individual program operating cost requirements.

Challenges for Military MRO Industry.

According to economical predictions and estimations, the value of the military aviation MRO market is expected to increase at a Compound Annual Growth Rate (CAGR) of 3.49% during the forecast period (2012-2022).

A significant number of countries are investing in the development of their domestic military aviation MRO capabilities by establishing strategic alliances and technology transfer agreements with established global manufacturers. In addition to improving the indigenous capabilities of a domestic firm, this provides foreign companies with an opportunity to cater to a new market. This is especially true in today’s economic scenario when companies are looking to maximize efficiencies and cut costs.

Though the global military aviation MRO industry is rising, it is currently facing a significant challenge in terms of skilled manpower to carry out the work efficiently. This shortage is now restricting companies in the amount of work they can take on which is primarily due to the lack of in-house training programs which is further attributed to the MRO industry moving away from traditional apprenticeship programs in an effort to cut costs.

Over the extended life of a military system or platform, the sustainment, repair and overhaul phase represents approximately 60-80 percent of the entire system lifecycle**.** With continued focus on outsourcing military aviation MRO activities, private OEMs are being asked to assume responsibility for the total care of these systems and platforms, even as cost pressures are increasing and resources are limited. Due to these factors, the military aviation MRO industry still faces significant challenges in resource allocation, information management and service management while delivering required MRO services for a component or an entire platform.

Conclusions

1. The LCC for the military Aviation is a very complex process using a model that allows the creation of scenarios based on assumptions about future cost drivers. The design of the model should reflect the complexity of the asset under investigation, the ability to predict future costs and the significance of the future costs to the Organization.
2. Improvements in reliability and maintainability of selected critical parts can greatly reduce significantly the O&S cost.
3. The increasing cost of operating and supporting weapon systems reduce funds available to develop and acquire new weapon systems and modify existing ones.
4. Projects that could lower these costs in fielded systems cannot compete effectively for funding against projects that enhance safety, readiness, or combat capability**.**
5. Setting performance requirements early in an acquisition program, without adequate knowledge of the total cost can lead to very costly and unstable system designs.
6. To establish accountability for reaching DOD's goals of significant reductions, the Air Force needs to establish O&S cost requirements for aircraft it is developing or procuring and for those that are already in service.
7. A significant number of countries are investing in the development of their domestic military aviation MRO capabilities by establishing strategic alliances and technology transfer agreements with established global manufacturers.
8. Though the global military aviation MRO industry is rising, it is currently facing a significant challenge in terms of skilled manpower to carry out the work efficiently. This shortage is now restricting companies in the amount of work they can take, especially due to the lack of in-house training and the prompt replacement of the aged or retired personnel.
9. DOD, GDDAE, HAF, HAI and private companies having MRO capabilities, have to improve their synergies according to the guidelines provided in National Defensive Industrial Strategy (ΕΑΒΣ).

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