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LIFE CYCLE COST ANALYSIS FOR MILITARY EQUIPMENT. LIFE CYCLE SUSTAINMENT PLAN AS MAIN INSTRUMENT

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Abstract:
One of the main characteristic of present days for Romanian Armed Forces is the switching accent from a numerous military corps with old equipment to a "slim" but stronger force using modern weapon systems. Suddenly, becomes a problem to fill the places with specialized people instead of using cold war weapon systems.

Of course, this situation is the consequences of aligning to 2% of GDP for defense sector and opens the way for modern weapon systems acquisitions. But when you need to fill the gap in so many capabilities in the same time in the same 2% envelope, you have to choose what to buy first and haw to mix the tempo of acquisitions. This paper is about a perspective of estimating the total cost of weapon systems, „from cradle to grave" and how to control, calculate and diminish the whole burden. One strong model is Life Cycle Sustainment Plan used by US Secretaries of Military Departments and the Directors of Defense Agencies.

Keywords*: lyfe cycle, analysis, defence, weapon , system*

1. Introduction

This paper discus the major systems acquisition process, and its underlying concepts, life-cycle costing, and cost estimation techniques and the strategies that enable the program managers to optimize the life-cycle cost of the system. There is no specific program (real data) it comprises specific evaluation on a estimating model in order to develop strategies which will eventually reduce the life-cycle cost of the system.

On the other hand, recent and constant 2 percent allocation for defense sector has already encouraged initiatives to enhance and develop capabilities in order to fulfill strategic objectives stated in planning documents. In real life, capabilities needs years to develop thus the political and top military leaders orders them as soon as it possible and imposes estimation on medium and long term for the financial implication. A very good approach is to determine all type of costs for the ownership of a system and also for creating a specific capability. Here is where Life Cycle Cost Analysis (LCCA) become mandatory, with all procedures and technics for estimating the costs. The lessons learned from the history of the modern warfare imposes that technological superiority itself is not sufficient to be the decisive factors in providing the competitive advantage but also the sustainment and operating performance. States must invest in designs and systems with improved long-term performance, especially in defense sector, where the life cycle of an equipment is long and usually extended over the planned terms.

In conclusion, the Guidelines for Life Cycle Cost Analysis instruct Project Teams to consider not only the "first costs" of a project but also long-term costs, including manpower, utilities, operations, and maintenance.

Just to be more complicated, we can add the fast proliferation and high obsolescence rates of technology as factors that must be involved in the requirements for the programs and also the need to connect the program achievements to immediate and concrete benefits for the eye of the public contributors.

2. Life Cycle Cost Analysis Concept

Life cycle cost analysis (LCCA) is an approach used to assess the total cost of owning a facility or running a project. LCCA considers all the costs associated with obtaining, owning, and disposing of an investment.[Ref2]

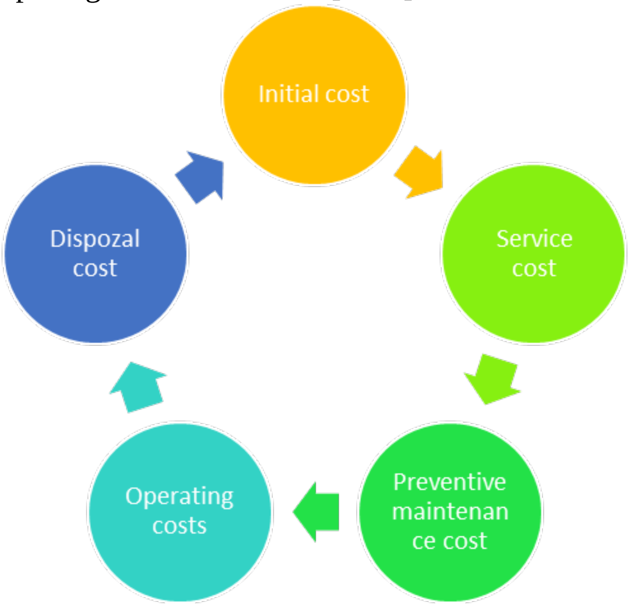


Figure 2-1: Life cycle cost concept," from cradle to grave"

Life cycle cost analysis is especially useful where a project comes with multiple alternatives and all of them meet performance necessities, but they differ with regards to the initial, as well as the operating, cost. In this case, the alternatives are compared to find one that can maximize savings. This analysis is mandatory especially when we have different initial cost, many types of operating costs, different procurement sources and all can vary in time.

2.1 Life Cycle Costs Elements

Various costs arise when procuring, operating, or disposing of a project. Project-related costs can be classified into initial costs, fuel costs, replacement costs, operation and maintenance costs, finance charges, and residual values.

For typical military acquisition programs the major components of the system LCC can be grouped as:

- Research, Development, Test, and Evaluation (RDT&E) costs;
- Investment Costs which include Military Construction (MELCON) costs;
- Production and Deployment (P&D) costs;
- Operation and Support (O&S) costs;

- Demilitarization and Disposal (D&D) costs.

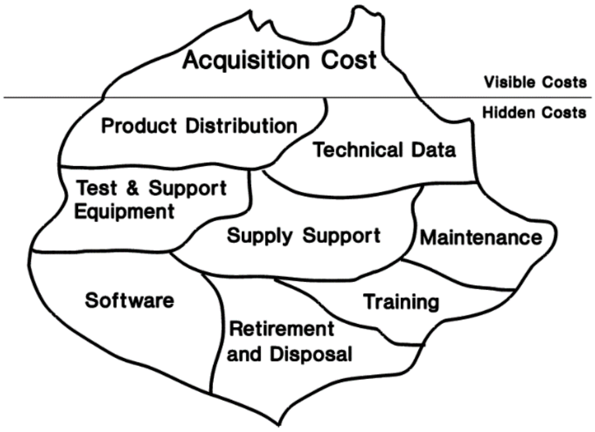


Table 2-2: Cost breakdown

Usually, the distribution of those LCC elements throughout typical system life is such that:

10% of LCC is RDT&E

30 % of LCC is Investment Costs

60% of LCC are O&S and D&D costs respectively.

As a consequence, the accent will be on diminishing the highest cost driver in LCC, O&S costs through improving system reliability to the extent feasible, and decreasing manning and logistics support requirements for the system.

To underline the complexity of the total costs I will perform a cost breakdown as it is made in the [Ref6].

a) RDT&E Costs

The costs associated with system development efforts constitute RDT&E costs and are as follows:

- Project management costs
- System test and evaluation costs
- Data collection and generation costs
- System engineering and integration costs
- Demonstration and validation costs
- Hardware research and development costs
- Software development costs
- Prototype manufacturing costs etc.

b) Investment Costs

Investment costs cover all the costs incurred to field the system to the operational units. We can classify investment costs into two major categories; military construction costs (MILCON), and Production and Deployment costs (P&D). MILCON costs are associated with construction requirements in order to manufacture, operate, and support the system throughout the system life. P&D costs refer to costs incurred for manufacturing and deployment of the system into the operational units. Generic component elements for Investment costs are:

- MILCON Costs
- Production tooling and test equipment cost
- Production set-up cost for lots

- Pre-production engineering non-recurring costs
- Recurring production costs
- Support equipment cost
- Initial spares cost
- Transportation costs
- Training devices costs
- New or modified facilities costs
- Warranty costs

c) O&S Costs

O&S costs are the total of the costs associated with operating and supporting the system through its operational life. As will be described further, the most important effort is performed to control O&S costs and resulted in creating LCSP tool for that phase of the system life-cycle.

Generic components O&S costs is such that:

- Personnel (Operations, Maintenance, Training etc.)
- Unit level consumption (Consumable Materials, Energy Consumption, Spares Replenishment, Training Munitions etc.)
- Maintenance Material Costs (O-level, I-level, D-level)
- Sustaining Support Costs (Support equipment maintenance and replacement, Sustaining engineering support, Software maintenance costs etc.)
- Indirect Support Costs (Personnel Support, Installation Support)

d) D&D Costs

D&D costs are incurred at the end of system life, and associated with disposal of the system with minimal environmental effect. The increasing level of environmental awareness by public, restrictive environmental regulations, and security considerations make the appropriate disposal process an imperative.

Calculating Life Cycle Costs. Concepts

The main challenge for LCC is obviously to calculate all types of costs. Some of them represents fix costs and many are variable. From the first estimation will be identified costs that can vary and influence the decision in choosing one alternative. Only relevant and significant costs in each of the categories above can be used to make investment-related decisions. Costs are considered significant when they are substantial enough to cause a dependable impact on a project's LCC.

All the costs involved are treated as base year values equivalent to present-day dollar amounts. LCCA transforms all dollar values into future year occurrence equivalents and then discounts all the values to their base dates. In such a way, it's easy to find their present value.

This section explains fundamental concepts behind LCCA and presents the standard Stanford LCCA approach.

A number of basic concepts underlie LCCA.

a) Time Value of Money

The value of money today and money that will be spent in the future are not equal. This concept is referred to as the "time value of money."

The time value of money results from two factors:

(1) inflation, which is erosion in the value of money over time

(2) opportunity cost.

For cash or existing capital, opportunity cost is equivalent to the benefit the cash could have achieved had it been spent differently or invested. For borrowed money, opportunity cost is the cost of borrowing that money (e.g., the loan rate).

b) Inflation

Inflation reduces the value or purchasing power of money over time. It is a result of the gradual increase in the cost of goods and services due to economic activity. By eliminating inflation from all escalation and discount rates, estimates of future costs can be made in current dollars and then returned to present value with the proper formulas. An estimate of the future behavior of inflation rates can be avoided.

The following formula factors inflation out of any nominal rate:

$$REAL = \frac{1+NOMINAL}{1+INFLATION} - 1$$

Where: REAL is the real rate NOMINAL is the nominal rate INFLATION is the inflation rate

c) Discount

Project costs that occur at different points in the life of a building cannot be compared directly due to the varying time value of money. They must be discounted back to their present value through the appropriate equations. The discount rate is defined in terms of opportunity cost.

The basic discount equation is as follows:

$$PV = \frac{F_Y}{(1-DISC)^Y}$$

Where:
PV is the present value (in Year 0 dollars)
FY is the value in the future (in Year Y dollars)
DISC is the discount rate
Y is the number of years in the future

d) Escalation

Most goods and services do not have prices that change at exactly the same rate as inflation. On average over time, however, the rate of change for established commodities is close to the rate of inflation.

Like discount rates, escalation rates are adjusted to remove the effects of inflation. The Escalation Rates table under Life Cycle Cost Parameters below lists the "real" escalation rates of various types of goods and services. Where the real escalation rate is close to zero or zero, the escalation rate for that category is essentially the same as the inflation rate.

The formula for calculating the future cost of an item with a known cost today and a known escalation rate is:

$$COST_{YEAR-Y} = COST_{YEAR-0}(1+ESC)^Y$$

Where:
COSTYEAR-Y is the cost at Y years into the future
COSTYEAR-0 is today's cost (at Year 0)
ESC is the escalation rate
Y is the number of years into the future

e) Study Life

The study life in LCCA is the period over which the costs of a project will be examined and will influence LCCA decisions. The study life may not be the same as the building life but may be the same as that of the longest-lived subsystem option under review. To make LCCA comparisons valid, the study life must be the same for all alternatives. [Ref4]

Calculation method

LCCA properly weights money spent today versus money spent in the future. All costs should be converted to common, current dollars and then summed to develop a total cost in present dollars for each alternative. This quantity is sometimes referred to as the net present value or the total cost in today's dollars. With the net present value calculated for each alternative, comparisons are simple because units are consistent. The best option is simply the alternative with the lowest life cycle cost or net present value.

The basic formula is as follows:

$LCC = C + PV_{RECURRING} – PV_{RESIDUAL\text{-}VALUE}$

Where:

LCC is the life cycle cost

C is the Year 0 construction cost (hard and soft costs)

PVRECURRING is the present value of all recurring costs (utilities, maintenance, replacements, service, etc.)

PVRESIDUAL-VALUE is the present value of the residual value at the end of the study life (note: these guidelines recommend his to be $0) [Ref4]

Uncertainty in LCCA Calculations

Uncertainty can be explicitly addressed in LCCA calculations, but it makes them much more complex. Each parameter used can be assigned a degree of uncertainty; these uncertainties can then be aggregated in statistically justifiable ways to measure the overall uncertainty of the result.

To make LCCA calculations as simple and straightforward as possible, the Stanford LCCA approach makes uncertainty an external qualitative consideration rather than a quantitative analytical one. Users should consider uncertainty throughout their LCCA studies and weigh the results qualitatively. For example, if an LCCA comparison of a variety of options shows a small difference in overall life cycle costs (e.g., 1%), then these costs should be considered equal. In other words, a small cost differential should not determine the best approach. In this case, the alternative with short-term benefits such as lower first cost, favorable environmental impact, or increased comfort for building occupants should be selected in accordance with project goals and budgets. [Ref4]

Many assumptions need to be made over the course of an LCCA study in order to generate enough data to produce results. These assumptions will strongly affect the results. All assumptions used in LCCA must be clearly stated and documented so that appropriate members of the Project

Team can validate them through the design process as costs, goals, and budgets change.[Ref4]

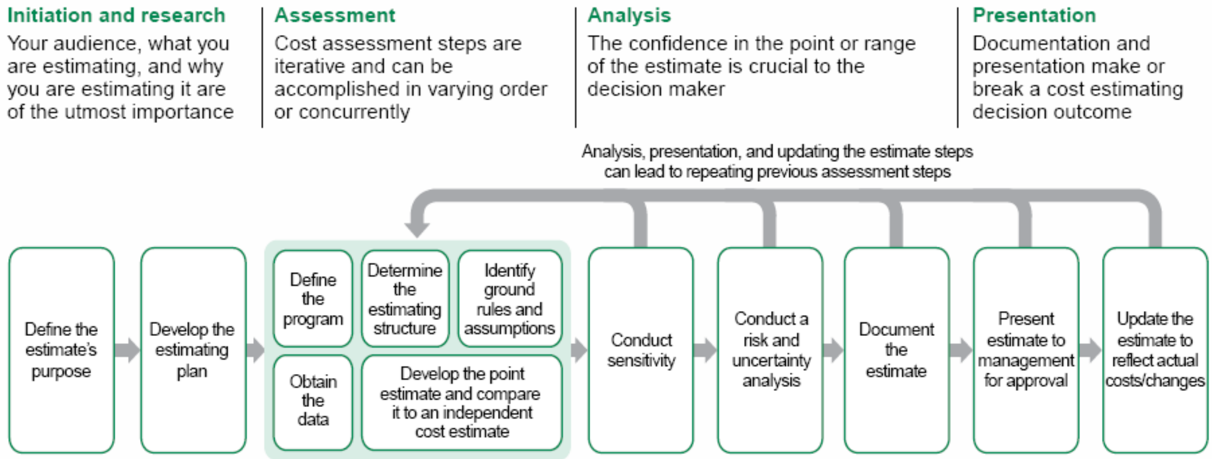
Cost estimations

Cost estimation can be defined as a process in which the financial resource requirements, which are required for developing, manufacturing, fielding, operating, and sustaining a system, are explored either for budgeting, programming, and funding purposes, or analysis of system effectiveness and analysis of alternative system designs.

Cost estimating is a recurring activity throughout system life rather than a one-time activity during the system acquisition period, and generally the quality of the estimates increases as the program moves through the phases of system life-cycle since the level of uncertainty decreases.

Table 2-3: Recurrent estimation in LCCA

The available methodologies for cost estimation are classified as the analogy approach, parametric techniques, the engineering approach, extrapolation from actuals, and the expert opinion approach. I will not insist in discussing those techniques in this paper, presenting a more practical tool, the Life Cycle Sustainment Plan, which includes also a lot of estimates.



Source: GAO.

Regardless of the methodology employed, there are some prerequisites in order to develop qualified cost estimates. First, all the relevant costs should be included into the cost elements of the system, which refers to completeness of the estimate. Second, the methodology employed in order to develop a cost estimate must be suitable to circumstances such as availability of data, and the purpose of the estimate etc., and must consider the differences with analogous systems' cost data in technology, and socio-economic conditions (which refers to reasonableness of the estimate). Finally, the assumptions upon which the cost estimates are based and cost estimation documentation must be supportable by the facts, be consistent within the known context, and be valid (which refers to consistency of the estimate).

3. Life-Cycle Sustainment Plan

When we discuss about LCCA for military equipment in most of cases the significance of analysis is no longer a tool for choosing between some alternatives. Especially in the cases of aur armed forces, the decisions will keep an important part of political argumentation and in the most important programs will be Gov-to-Gov agreement. In that cases LCCA will be very useful like a practical tool for reducing the financial pressure and overall cost in the entire LC of equipment. This plan integrates models, estimates and analysis applicable to a very large variety of military equipment. This paper will present LCSP using models with fictive but realistic data just to exemplify the tool.

The Life-Cycle Sustainment Plan (LCSP) serves a valuable purpose as a tool in coordinating the efforts, resources, and investment of the DoD Materiel Commands such that down time for fielded weapons systems is managed through deliberate productivity improvement steps that continually lower the cost of readiness. The LCSP support the conditions for the Services to analyze the decision space for how to control Operating and Support (O&S) cost. This annotated outline was structured as a framework to assist weapons programs in thinking through the set of planning factors that must be integrated to achieve the sustainment results quantified in user specified requirements. An LCSP that logically integrates requirement, product support elements, funding, and risk management, establishes the groundwork for successful communication with Congressional, Office of the Secretary of Defense (OSD), and Component oversight staffs.

The whole "product support package" consists of all or a subset of the following product support elements:

- Product Support Management
- Supply Support
- Packaging, Handling, Storage, and Transportation
- Maintenance Planning and Management
- Design Interface
- Sustaining Engineering
- Technical Data
- Computer Resources
- Facilities and Infrastructure
- Manpower and Personnel
- Support Equipment
- Training and Training Support

Additionally, the product support package includes the agreements between program offices and government and contracted support providers.

Looking at the document can be noticed that the term "plan" can be easily replaced with "the strategy", having a set of tasks and activities required to be implemented. This outline aims to capture the strategy and the set of planning tasks and activities to stimulate critical thinking for managers and teams responsible for sustainment planning. The plan let the managers to have initiative in choosing what to measure and how to estimate costs or even to propose upgrades or changes in the program (major upgrades or modifications, adjustments to program scope or structure, or a revision to the sustainment strategy).

In addition to ensuring program's product support strategy influences a system's design, the LCSP is the primary program management reference governing operations and support—from Milestone A to final disposal. The LCSP is not a static document. It evolves throughout the acquisition process with the maturity of the system and adjustments to the program's life-cycle product support strategy. To remain relevant and current, the LCSP is updated every five years or upon a major program change to the program.

Program managers must project the timeline to obtain necessary stakeholder buy-in and approval of the sustainment strategy and completion of the LCSP to support program decision points. In order to minimize document development timeline and rework, it is recommended that parallel staffing processes be considered.

Further, there are presented major chapters of the LCSP.

Product Support Performance

In this chapter the program managers have the requirements for sustainment performance and also the observed/ measured. The obtained data are used to evaluate how well the adopted strategy meets the outcomes. These desired outcomes are established by Military Departments and are expressed as program requirements in the form of Key Performance Parameters (KPPs), Key System Attributes (KSAs) or Additional Program Attributes (APAs) through initial planning documents.

Product Requirements

Here, the LCSP is to identify all explicit, implicit or derived sustainment requirements from program documents for every domain or even discrete components and determine how to measure and evaluate them. The values can vary from Initial Operational Capability to Final Operational Capability and to the time of disposal, especially in reliability parameters or training parameters.

For each sustainment requirement, identify which are KPP/KSA/APAs set of parameters, threshold and objective values, section of the Test and Evaluation Master Plan (TEMP) covering that metric, along with projected values at IOC, Full Operational Capability (FOC), and full fielding. The document may contain the reference in contract which impose the requirement. Further there is an example of key parameters as defined in this section.

Requirement (KPP, KSA, Derived requirement)	Threshold / Objective	IOC FY XX	FOC FY YY	Full Fielding FY ZZ
Availability	66% / 82%	100%	100%	72%
Mission Reliability	46 hrs/ 61.6 hrs	46 hrs	46 hrs	46 hrs
Logistics Reliability	MTBF 3.5 hrs /4 hrs	3.5 hrs	3.5 hrs	3.5 hrs
Maintainability				
Corrective Maintenance	1 hr/ 0.5 hrs	1 hr	1 hr	1 hr
BIT Fault Detection	>98%	98%	98%	98%
BIT Fault Isolation	>95%	95%	95%	98%
O&S Cost Avg Annual	$4.2M per unit per year			$4.2M per unit per year
Mobility	4 pallets per 3 ship formation 2 pallets per 2 ship formation	5 pallets	4 pallets	4 pallets
Transportability	Movement by CH-47	1	1	1

Training	60 hr crew differences / 40 hr	60 hr	N/A	N/A
Supply Chain Responsiveness /Customer Wait Time	15 Days (T)/ 5 Days (O)	15 Days	10 Days	5 Days

Table 3-1: Sustainment Performance Requirements

Sustainment Performance

For some of the defined Key Performance Parameters (KPPs), Key System Attributes (KSAs), Additional Program Attributes (APAs) there is a need to indicate the method or test to measure. This will provide data for demonstrations and tests that include evaluation of sustainment elements and assures the measurability of major feature that affects sustainment or sustainment cost (e.g., cost driver), its schedule or performance goal.

Test	Metric/ Feature	Schedule	Performance Goal	Estimated Value	PSM Assessment
Early User Test	Low observable coating on external surfaces	1st Qtr CY2012 /3rd Qtr CY2015	Repair 1 sq ft area in 4 hours	OT&E tested value: 7 hr	achieved only 50% of performance
Reliability GrowthTest (RGT)	Intelligence, Surveillance, and Reconnaissance (ISR) system reliability of 46 hrs MTBSA	Development Test Eval 1st Qtr CY15	46 hrs	46 hrs	TBD
Initial Operational Test and Evalution (IOT&E)	All metrics in Table xx	1st Qtr CY20xx	See Tables xx	See Tables xx	TBD
Supply Chain Responsiveness /Customer Wait Time	15 Days (T)/ 5 Days (O)	15 Days	10 Days	5 Days	

Table 3-2: Sustainment Performance Assessment/Test Results

During the life cycle, the values will be changed at every update of the contract or at midlife update of the equipment. Also, can be the base for revision of the program or can be the reason for sustainment plan if there are not met the planned requirements.

The Military Services should begin product support planning as soon as the Milestone Decision Authority has determined that a Materiel Solution is needed to satisfy the capability requirement. This timing often precedes formal establishment of a program of record and staffing of a program office. Antecedent systems often provide valuable lessons and performance benchmarks that new programs may use to establish performance improvement objectives and Should Cost initiatives. Building the plan, managers should identify the mission critical subsystems and strategy to keep these subsystems operational. Mission critical systems are those systems whose failure would prevent the platform from continuing its mission and force the platform to wait for repair.

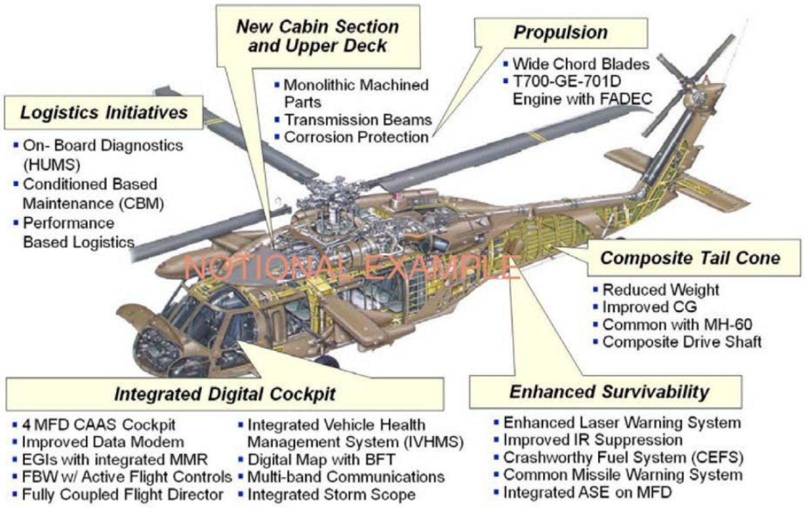


Figure 3-3: Weapon system breakdown by subsystems

The decomposition of the sustainment requirement and the system architecture and allocation against the product support elements necessary to satisfy the requirement should be included in all plans. More than one drawing may be needed to illustrate the major features affecting product support. For exemplification, In Figure 3-3 is presented a hello by its subsystems.

The complexity of system of systems maintenance may lend itself to a different depiction than the one provided in next Table 3-4.

Sub-sys***	Proprietary Intellectual Property	Data Rights	Function	Integrated Product Support Elements *																			
				Maintenance										Software Support		Transportation (PHS&T)		Config. Control**		Technical Data		Training	
				Level 1				Level 2				Level 3											
				O-1	O-2	O-3	CR	I-1	I-2	I-3	CR	Depot	CR	O	C	O	C	O	C	O	C	O	C
Airframe†	None	Unlimited												F		F		F		F		F	
			Servicing/Inspections	F	F	F																	
		OMIT data	Corrosion Control/Treatment	F	F							NI											
		OMIT data	Repair	F	L			F	L	F		NI											
Power Plants																							
Engine†	Partial	Negotiated License Rights												F		F		F		F		F	
		OMIT data	Servicing/Inspections	F	F	F		F	F	F		NI											
			Assemble/Disassemble	F	L			F	L	F													
			Repair					F				NI											
APU†	Partial	Negotiated License Rights													A	TR	P-A		A		A		A
		OMIT data	Remove & Replace	F	F	F	F																
			Repair & Overhaul				A				P-A		A										
Avionics																							
ISR	Yes	Negotiated License Rights													ISR		ISR		ISR		ISR		ISR
		OMIT data	Inspections	F	F	F							ISR										
			Functional test & adjustments				ISR	ISR	ISR	ISR	ISR		ISR										
			Repair				ISR	ISR		ISR	ISR		ISR										
Fire Control†	None	Government Purpose Rights												F		F		F		F		F	
		No expiration date	Inspections	F	F	F						TK											
		OMIT data	Functional test & adjustments					F	L	F		TK											
		OMIT data	Repair					F		F		TK											
		OMIT data	Diagnostics Software																				
Other	In Work	Government Purpose Rights													A	TR	P-A	F		F		F	
		No expiration date	Inspections	F	F	F						TK		F									
			Functional test & adjustments	F	L			F	L	F		TK											
			Repair					F		F		TK	P-TBD		P-TBD				P-TBD				
Life Support	TBD	Unlimited												F		F		F		F		F	
			Inspections	F	F	F																	
			Functional test & adjustments	F	F			F		F		NI											
			Repair																				
Test Equipment																							
Avionics	Yes	Unlimited	Diagnostics Software									NI											
			Hardware					F	L					F		F		F		F		F	
Propulsion	Yes	Negotiated License Rights	Diagnostics Software																				
		OMIT data	Hardware					L					B		B		B		B		B		B
Simulator																							

* Can include other areas of consideration in addition to IPSEs
** Includes design and logistics management responsibilities

*** Expand as required to highlight major sustainment cost or availability drivers. Expand as program moves toward MS C.

† Core

Maint. Level Codes

O-1: Ashore Squadrons & Aviation ships
O-2: OCONUS Detachments
O-3: Detachments aboard non-aviation ships
I-1: Major CONUS Ashore & Aviation Ships AIMDs
I-2: Minor CONUS Ashore Sites
I-3: OCONUS AIMDs
CR Commercial Repair
F Full organic capabilities
L Limited capabilities

Organizational Codes

NI NADEP North Island
TK Tinker – AMC Tinker
ISR ISR Contractor TBD
A Contractor A
B Contractor B
TBD Contractor TBD
P Organic/Commercial Partnership
TR TRANSCOM
C Contractor

Table 3-4: Maintenance system of a hello

In such cases the plan will contain information on many concurrent domains and will consider alternative formats for providing this information. Required information for a full picture of maintenance support includes: maintenance concept, type of work to be accomplished at each maintenance level, expected or known provider of the maintenance, and also sustainment provider/level for the Classification/Distribution Statement.

The figure must list the program's planned supply chain performance metrics. Additionally, the figure must include joint support, if planned, and the roles and responsibilities of the major agencies, organization and contractors planned as part of the system's product support. Consideration are given to DoD enterprise solutions for weapon systems, subsystems, or components that are alike, similar or already supported by a government supply chain.

The plan contains also a graphic that illustrates the major elements of the system's Product Support Strategy, both government furnished and contractor delivered, that will be used across the entire spectrum of system operations, to include peacetime, contingency, wartime, and emergency surge scenarios as applicable. The manager will coordinate to Service decision maker to fulfill the availability and affordability requirement. He also must also use data on capabilities and limitations of the logistics enterprise to influence system reliability design trade decisions. Additionally, this figure provides the product support functional breakdown necessary to develop effective contracted product support arrangements.

Product Support Functional Area	Location/ proposed location	Planned sustainment performance metrics	Planned Contracted Support
Program Head Quarters (Product Support Management)	Quantico/Stafford, VA; Warren, MI	n/a	Mix contract and gov't
Test Facilities	Aberdeen, MD; Yuma, AZ; Huntsville, AL	Test s execution within 5 days of schedule	All gov't
Logistics Support	Albany, GA; Barstow, CA; Red River, TX, Multiple throughout CONUS and AOR	Configuration support turnaround time, backlog, fill rate	Mix contract and gov't
Maintenance Depots	Albany, GA; Barstow, CA; Red River, TX	Avg Repair cycle time, Reset Time	All gov't
DLA Support	Columbus, OH, Philadelphia, PA, DDRT, DDKS, DDKA	Avg Fill Rate: Days supply	All gov't
Contingency Support Activity	Multiple throughout AOR	% ASL/PLL stocked, Zero bal w/ due out critical readiness drivers, days supply on hand,	All contract
Contingency Maintenance Depot	Kuwait	Throughput (vehicles/wk), Avg Repair cycle time (mission capability, battle damage), cost (per repair type, operation level)	All contract

Table 3-5: Product support breakdown

There are few domains reflected in the strategy, like following:

Obsolescence Management - Provide data for the management plan, known or predicted obsolete parts for all program system specifications, obsolete parts with suitable replacements, and actions to address obsolete parts without suitable replacements.

Competition in Sustainment - Provide information for planned competition in product support. Include all competition opportunities under consideration and note any small business opportunities. Not all competition is open to small business opportunities but there are many chances to reduce costs encouraging competition.

Cyber security – There is mentioned a Program Protection Plan which is the program's primary document for managing a program's protection of their technology, components, and information throughout the system life cycle. The Program Protection Plan includes areas that directly impact sustainment including Cyber-security Strategy, Anti-Tamper Plan, and Supply Chain Risk Management. This section of the LCSP is reserved for appropriate cyber security and related program protection planning details and to identify the PM responsible for the Program Protection Plan during system sustainment and disposal.

Sustainment Relationships – Ideea is to identify relationships (industry, Service staff elements, other DoD Components, international partnerships, etc.) for the product support strategy. List planned provisions to ensure product support providers remain viable throughout the life-cycle. The data can be a figure, table, or diagram but must include all product support stakeholders.

Product Support Arrangements - In this section, list all product support arrangements (contract, task order, agreement or non-contractual arrangement within the government) for systems, subsystems or components. For every provider there is a database where there is

Performance Agreements with Organic Product Support Providers				
Organization	System	Activity	Documentation	Metrics
Corpus Christi Army Depot	1. T70-GE-701D 2. Chord Blade	1. 3000 hour Depot Overhaul 2. Chord Blade Repair	Memorandum of Agreement (MOA) with Headquarters Army Materiel Command (Estimated Completion Date (ECD): 3d Qtr. 2017)	1. Repair Cycle Time = 30 days 2. Repair Cycle Time = 14 days
Fleet Readiness Center (FRC) Southeast	Common Missile Warning System	1. Sensor Repair 2. Sensor Spares	MOA with AMC and FRC South East (ECD: 2018)	1. Repair Cycle Time = 14 days 2. 88% Army supply system spares
Defense Logistics Agency (DLA) Aviation	Common Missile Warning System	Field spares	TBD	85% spare parts stockage at field level
Letterkenny Army Depot	Enhanced Laser Warning System	1. Depot Level Reparable (DLR) Repair 2. Spares support	See PEO Memo, Next Gen Vertical Lift Support Agreement, June 23, 2014	1. Repair Cycle Time = 14 days; System NMCS >=91% 2. 92% spare stockage at field level

mentioned:

- Name and Contract line Item Numbers (CLINs)
- Organization and points of contact
- Products and period of performance covered, including remaining actions to put the contract into place
- Responsibilities/authorities and functions
- Performance metrics and incentives
- Status of Cost and Software Data Reporting (CSDR) planning/reporting

Performance Agreements - List the planned or current agreements that are part of the product support package. Information provided must be consistent with the Acquisition Strategy. An example of performance agreements list for our proposed case is presented below.

Table 3-6: Performance agreements for a maintenance system of a hello

During filling this section of the LCSP the managers has the option to consider or not the use of commercial technologies (especially IT) when it comes about reducing cost or make decision in the case of software packages that can raise availability or maintainability issues during all type of conflict.

Program Review Issues and Corrective Actions

The purpose of this section is to provide a single location to track and monitor information on the development of a system's product support as part of a program's standard review processes. Provide data for reviews in which the product support team participates, the sustainment findings from the reviews, as well as corrective action and completion dates. The data can include entries for planned reviews. Data should include information from reviews accomplished for all subsystems, supporting systems (e.g., trainers, simulators) or system of systems that impact the system's product support.

As a conclusion the program managers has to conclude if the reviews conducted to date resulted in changes to product support strategy or if any product support strategy assumptions confirmed during the reviews.

Integrated schedule

Provide the product support schedule consistent with the program's integrated master schedule. Schedule items include but are not limited to:

- Significant program activities (i.e., activities which must be performed to produce, field, and sustain the system). Examples include: program and technical reviews (including ILAs), RFP release dates for sustainment related contracts, software releases (post-FRP), sustainment contracts, CLA/DSOR process, IOC, fielding plan, and Product Support Business Case Analysis (BCA).
- Major logistics and sustainment events for product support elements with specific emphasis on materiel and data development and deliveries.
- Major activation activities for sites in the supply chain required to support the system, to include

maintenance (field, depot, overseas, ashore), supply, and training. Include events for contractor support (interim, long term, partnerships).

- Interdependencies and interactions with other weapon systems or subsystems that are part of the platform.

Cost and Funding

Operation and support cost represents the big leaf of funds during the LC. As mentioned before, majority of them are estimations performed by various estimation method. The purpose of this section is to track the evolution of the O&S framing assumptions, cost estimates, and cost actuals as the program progresses through the life-cycle.

Through brief text and graphics, provide O&S cost data on the antecedent/ legacy system(s) (if applicable). If there are similar antecedent systems that will be used as reference for estimates, with a good probability. After that is the time to identify major differences between the legacy system and the program (e.g., differences in manning, maintenance, unit quantity, expected service life). For the program, provide each major O&S cost estimate that has been performed. Sets of data will include information to highlight any major changes from one estimate to the next, will include both assumption and technical/programmatic changes.

The O&S cost data for the system represents its **O&S Will Cost**. As the system matures and evolves through its development, fielding, and operation, update data to provide a comparison of how the O&S estimate has evolved over time, the date of the estimate, and planned updates.

The following figure (Table 3-7) is a notional example for O&S data using a graph but it can be a description, table, or other format that is most appropriate for the program to display the required information.

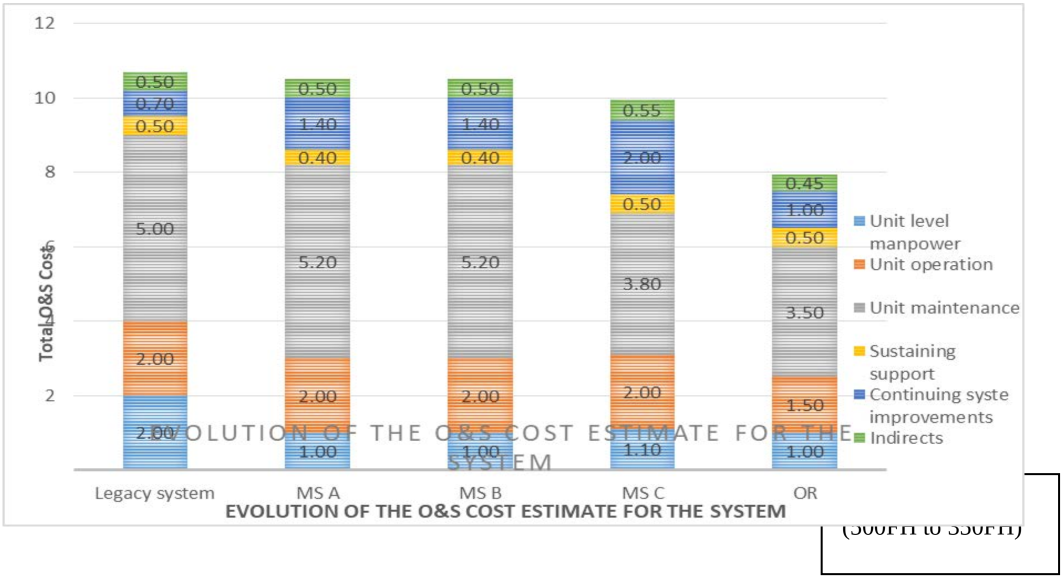


Table 3-7: Evolution of the O&S Cost Estimate for the hello

After Milestone C, this section should include a comparison of actual O&S cost to estimates. Provide data on major changes affecting O&S cost (e.g., assumptions that have changed – Operational Tempo was planned for 500 flying hours per aircraft per year, actual usage has been 350), subsystems or components reliability, etc., and actions planned or implemented to address O&S cost growth.

In the same section is comprised as reference the **Disposal costs** of the antecedent/ legacy system and compare the evolution of the **Disposal cost estimate** of the new system against that reference. To provide data on the system's current disposal cost estimate is necessary to include the estimate source, the date of the estimate, the next planned update, major assumptions, and where complete estimate documentation is available. All disposal/demilitarization costs should be included, regardless of funding source or management.

In this model case there is no possibility to sell product at residual value, but this could be a possibility for many systems. Here, it will only provide a comparison of how the system's disposal estimate has evolved over time.

O&S and Disposal Cost Drivers

The purpose of this section is to identify the elements of the system that are the greatest contributors to the estimated O&S and disposal costs. Include specific variables driving O&S

cost and the actionable Should Cost initiatives the program plans to use in controlling such costs. Should Cost initiatives specific to disposal cost should be included if disposal cost is expected to be a sizeable portion of the life-cycle cost.

Identify expected or known (post-Milestone C) O&S cost driving categories using the Cost Assessment and Program Evolution (CAPE) O&S cost elements. Figure 7-3 shows one way to portray this information. Once the most expensive CAPE O&S cost elements are determined, further analysis should be performed to decompose those cost elements into the specific labor and material costs that contribute to that element. Actionable O&S cost drivers early in the acquisition process often can be addressed through the system's design. After fielding, the reliability of a subsystem's components may be a cost driver and require re-design.

At Milestone A, cost driver analysis will likely take the form of comparison to legacy system costs. From Milestone B to Milestone C, cost driver analysis should be based on the system design and developmental testing. After Milestone C, cost driver analysis should be based on system actual costs, including initial operational testing and evaluation, as illustrated by the following figure.

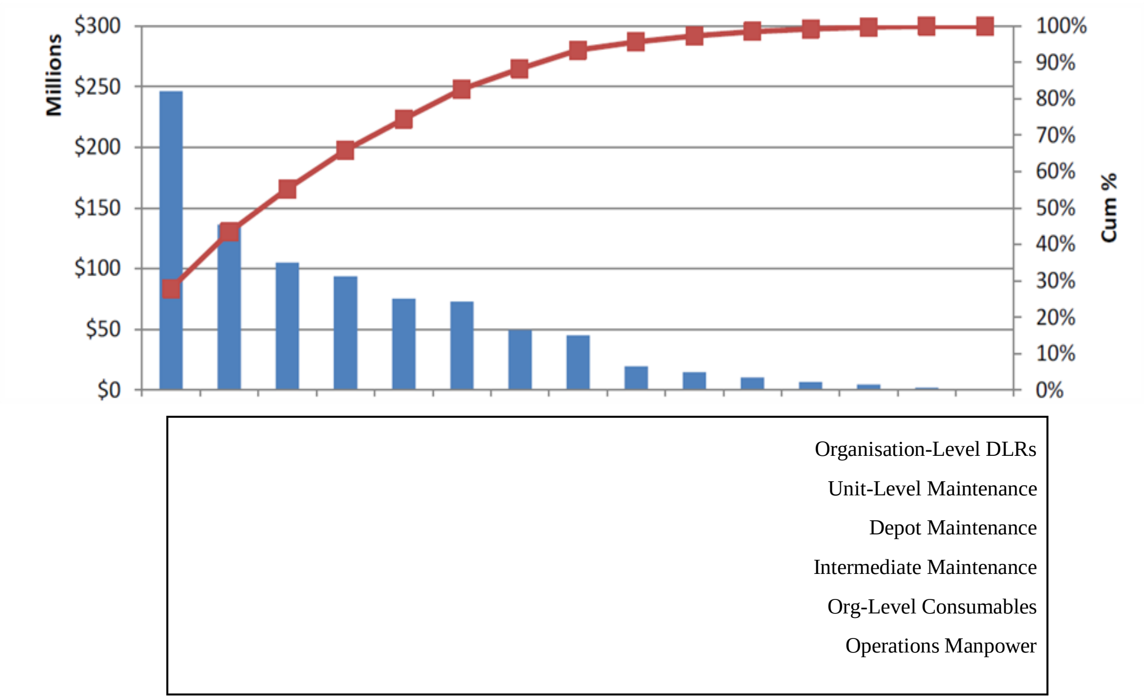


Figure 3-8: System Actual Costs, Including Initial Fielding

4. Conclusions

Modern war, even we keep the classical view or adopt the newest asymmetrical type, moves the accent from the number of fighter to the impact of the weapon. Maybe in few decades the war will be endured by programmable robots and computer controlled weapon systems. Starting from here, it is natural the interests of nations to invest in more and more sophisticated weapons, where even the thinnest technological advantage can bring the victory. I can say that even the victory is no longer the combat clash win and is brought by the capacity to sustain the battle.

As all the main program shows, no matter the domain, the present value of maintenance, operations, and utility costs are bigger than the initial investments so anyone could not think at an acquisition program without a LCCA. Maybe in some domains (buildings) the operation and maintenance costs are more predictable and share almost a half of the total investments, but in the case of military equipment acquisition these are big actors when it comes about allocating a budget. In addition, there are more factors that will influence the O&S costs on the entire the systems acquisition process, like operation environment, operation tempo or supply chain characteristics.

The conclusion cannot be other that every investment in weapon systems should be approached from a view that will comprise the entire life time of the equipment, "from cradle to grave".

The weapon systems acquisition process should be robust to incorporate the latest technologies into system solutions, it should provide the best value to the acquiring organizations, and it also should realize best utilization of limited defense resources. Instruments and mechanisms like LCSP are originated from the need to be more and more efficient in spending resources for defense and, probably, will be assimilated at the level of NATO alliance in a form or another.

Finally, it is no so important how many weapon systems you own or how sophisticated them like the number of weapon systems are you can use and sustain in battle. From this perspective it becomes essential to perform LCCA in defense sector.

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