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**A LOGISTICS LIFE CYCLE COST GUIDE
FOR THE PROGRAM MANAGER**

by

Lt. Col. Martin D. Carpenter

**A PAPER SUBMITTED TO THE FACULTY
IN
FULFILLMENT OF THE CURRICULUM
REQUIREMENT**

**Advisors: Colonel Glenn C. Easterly
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ABSTRACT

TITLE: A Logistics Life Cycle Cost Guide for the Program Manager

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Logistics life cycle costs make up the vast majority of the cradle to grave expenses associated with the procurement of a new weapon system. A logistics life cycle cost (LLCC) guide is important because it provides the program manager with essential cost data during both the pre and post contract award phase of a weapon system acquisition program. This data can be used to determine: (1) to whom a contract should be awarded; and (2) to accurately project, and continuously update, the multi-year post acquisition weapon system support costs which are increasingly coming under close scrutiny because of budget reductions.

BIOGRAPHICAL SKETCH

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CHAPTER I

INTRODUCTION

It is the intent of this paper to provide any program manager with a guide to estimating logistics life cycle cost (LLCC) for a system. The thoughts and opinions in this paper are based upon my experiences as a government employee working on the acquisition of electronic systems for the Naval Air Systems Command, and as a private sector employee of Allison Gas Turbine providing aircraft engines to the military. While the focus of this paper will be on military acquisition programs, the matrix aspect of the guide can be modified and used for other types of government or commercial programs. Since government program managers generally receive a significantly greater amount of training in the life cycle cost arena than do those in private industry, the target audience for this paper is primarily the private industry program manager and his/her staff. This guide will not have significant detail, but will focus on the elements that make up LLCC, what should be considered when defining these elements, and, *one* method in which they can be packaged to provide program logistics costs. Hopefully it will become another tool in the program manager's tool kit to help properly define the scope of a program, ensure that the program stays within budget and is completed on time.

Logistics life cycle cost is the measurement of the price of an integrated logistics support (ILS) program. The importance of accurately identifying that cost becomes apparent when the objectives of integrated logistics support are addressed. These ILS objectives are:

- to develop support requirements that are related consistently to design, readiness objectives, and to each other
- to effectively integrate support considerations into both the system and the equipment design
- to identify the most cost-effective approach to supporting the system when it becomes operational

- to ensure that the required support structure elements are developed and acquired (2:174).

In a perfect world, once a system was designed, produced and fielded, there would be no "care and feeding" required. It would:

- require no fuel to operate
- never fail, therefore no spare parts or maintenance personnel would be needed
- not require training programs, technical publications, support equipment, support personnel, packaging, handling, storage and transportation or facilities, etc.

In short, once a system was fielded, it could basically be forgotten about. While no program manager in the acquisition business actually forgets about integrated logistics support, many do, regrettably, *wish* they could forget about it and deal with ILS accordingly.

In some military system acquisition programs, logistics takes second place to the engineering and development efforts. The program manager, whether it be the government's or the contractor's, is primarily concerned with achieving a functional system design, building prototypes and ensuring a successful completion of test and evaluation. Some degree of integrated logistics support is always contracted for, but there are times when the government and/or the contractor may not direct the money or the manpower to adequately complete the effort. This usually occurs when significant technical problems arise or when total program resources are limited and short term trade-offs have to be made. Their attention may not re-focus on logistics and support of the production system until about the time the system enters operation in the field. Only then do they begin to realize the price of the trade-offs that they have made. By then it may be too late to undo decisions that might have been made differently had additional information been available earlier.

This paper contains three major sections: (1) a discussion of the importance of a logistics life cycle cost matrix from the perspective of both the government and contractor program manager, as well as that of the customer--the government; (2) a look at the various

uses for a LLCC matrix and; (3) the development and description of a LLCC matrix and a demonstration of its use.

CHAPTER II

IMPORTANCE OF A LLCC MATRIX

The Customer's (Government) Perspective

When the government decides to acquire a system for the military, its goals are no different than that of a commercial customer acquiring a non military system. It wants a system that will adequately accomplish the task for which it is being procured, be priced as realistically as possible, and have minimum logistics costs. The elements of an adequate logistics program, and the associated costs, must be addressed and controlled early to keep total program costs down. While the vast majority of the expenditures on a program occur after Milestone II, the bulk of the life cycle costs *committed*, and therefore difficult to change, occur *before* Milestone II (1, 3-C-4).

A simple but comprehensive logistics life cycle cost matrix, defined properly and calculated with currently available spread sheet software, can provide the government with cost figures that can assist it with: (1) pre-contract award analysis capability; (2) the establishment of comprehensive criteria for source selection; (3) cost benefit analysis/trade study evaluations and; (4) post award contractor performance review capability. From my experience however, logistics objectives for a system, developed through the logistics support analysis (LSA) process, currently have little influence on the above mentioned uses. The result is that many times the final logistics requirements will exceed the budgeted financial and manpower resources allocated to meet those requirements because earlier requirements were not factored into the decision making process. It is in the best interest of the government/customer to properly identify logistics requirements and their associated costs early. A workable logistics life cycle cost matrix, utilizing realistic input data in order to provide an unbiased output, can

save the government money, the program manager headaches, and provide the end user a better product with which to operate.

Government Program Manager Perspective

The three basic parameters of acquisition that the program manager must concern himself/herself with are cost, schedule and performance. A change in one will almost always mean a change in one or both of the other parameters. For the government program manager, cost and the technical portion of performance are generally the two main drivers with emphasis varying from program to program between the two. Once a contract has been awarded, the program manager has specific cost and total (technical and support) performance requirements that he/she must balance. A LLCC matrix can help the program manager in the decision making process as he/she begins to face the inevitable trade-offs that occur between the two.

The matrix can provide the program manager with cost data for various maintenance options, spare parts inventory requirements, energy consumption estimates, support equipment requirements, etc. It allows the program manager a relatively easy way to compare various integrated logistics support (ILS) options and their long term financial impact on the program. An optimum ILS package, that balances the level of support with long term cost, can be estimated and then monitored as the program progresses.

Another valuable use for the LLCC matrix is to analyze the impact of various design options for a system and the impact of each on the logistics support required to keep it operating. Recently there has been a great deal of emphasis on up front logistics support analysis and the positive influence it can have upon system design. MIL-STD-1388-1A proscribes five major LSA task categories that must be accomplished when a program is initiated. They are:

1. Program, Planning and Control
2. Mission and Support Systems Definition
3. Preparation and Evaluation of Alternatives

4. Determination of Logistics Support Resource Requirements

5. Supportability Assessment (1:4-R-2)

The data resulting from the performance of the LSA tasks is then documented in the logistics support analysis records (LSAR) per MIL-STD-1388-2A or in Relational Data Tables per MIL-STD-1388-2B. This results in output summaries or other logistics products that the program manager can use in his decision making process (1:4-R-1). While adherence to the MIL-STD-1388 documents is now a contract requirement on most programs, its actual influence upon system design is still minimal at best. Part of the reason for this is the inherent reluctance of engineers to change their design for other than technical performance related issues. However, the real reason probably lies in the fact that the program manager has no verifiable means to demonstrate the long term logistics impact of different design options. A LLCC matrix can take the support requirements for each option and approximate the financial impact, over the operational life of the system, thus giving the program manager the information he needs to make programmatic trade-offs.

Contractor Program Manager Perspective

The situation for the contractor program manager is much the same as it is for the government program manager when it comes to the cost, schedule and performance of a program. However, the contractor has one additional element under the cost parameter that the government program manager does not have--profit margin. Cost overruns on firm fixed price contracts are eaten by the contractor unless he can show that the government directed the scope or schedule changes that have forced the increase in cost. Utilizing oversimplified options, if a company is overrunning a firm fixed price program, and therefore not making a profit, it may: (1) go out of business, leaving the government with no program; (2) force the government to cancel the program (e.g. the A-12), once again leaving the government without a program; (3) force the government to "eat" the cost overruns or; (4) stay in business but avoid government programs in the future. Now that the government is getting away from firm

fixed price developmental contracts, and going back to cost plus contracts, the risk for the contractor is reduced while the risk for the government is increased. The importance of accurate life cycle cost estimates up front in a program is very apparent. Otherwise it can become a very costly situation for the government.

It has been my experience that contractor program managers do a poor job of telling their management, as well as the government program manager, the realities of logistics life cycle costs for any or all of three reasons. First there is a strong tendency to "shoot the messenger" when either corporate or government management hears news they don't like, true or not. Second, management may ignore the news, even if they do believe it, because the resources are not available to accomplish the tasks. And third, even if management is open to real world data, the current tools being used to project LLCC lack credibility. While a LLCC matrix cannot prevent the first or second reason for communication failure, it can improve the reception LLCC data receives by providing a credible means of projecting costs. A LLCC matrix can be a valuable tool for the program manager that can enable him/her to better stay within cost estimates, and, hopefully maintain a reasonable profit for the company.

CHAPTER III

USES FOR A LLCC MATRIX

Pre Contract Award Analysis

A potentially valuable use for a logistics life cycle cost matrix is during the pre contract award analysis of a conceptual system. When Phase 0 of an acquisition program is complete, a LLCC matrix could provide a comparison of logistics costs for various designs as well as an overall LLCC "should cost" figure to better justify funding for program initiation.

In comparing several design options, various maintainability and supportability issues could be examined on paper. Their impact upon system performance and acquisition costs could then be addressed by the engineering and the financial departments. Comparison of conceptual design options on logistics life cycle costs could help identify the optimum design, from a total life cycle cost perspective for the stated requirements, and assist in developing the final specification. Additional time and money spent on a better front end analysis will most likely save a considerable amount of money over the operational life of the system.

Once an optimum design specification has been agreed upon within the government, an overall LLCC "should cost" figure can be determined to assist in justifying program costs to higher level reviewers and decision makers. The same in-depth analysis that helped select the optimum design also provides a considerable audit trail to justify acquisition funding.

Government acquisition programs undergo great scrutiny and require large quantities of justifying documentation. Also, if *realistic* data is used in the matrix, by both the government and the contractor, cost overruns could be minimized since credible numbers would be used up front. As with any formula, model or matrix, the accuracy of the answer is a function of the data used to arrive at the answer.

Criteria for Source Selection

Having been involved in the source selection process as a government employee, I have found the process to be a somewhat subjective one with only a moderate amount of objective criteria below the surface of the specifics of the specification. Generally, if the contractor says he will meet or exceed the specification, and is the low bidder, he gets the contract. As history has shown, this is not a very good indicator of success. In any environment, but certainly in today's austere fiscal environment, a much better analysis of a design in Phase 0 can save the government money. The additional benefit of a better analysis is that specific criteria can be developed to ensure that bidders understand the factors that are involved in meeting the proposed contract requirements.

A logistics life cycle cost matrix provides more than just a total cost figure. Each logistics element provides a guide as to what items should be considered when an integrated logistics support program is being put together. The more scrutiny each logistics element receives in the early stages of a program, the less likely something will be overlooked that could impact the program later. The Phase 0 analysis of logistics elements and sub-elements provides criteria to ensure that the bidder(s) understand what is involved in meeting the contract requirements. This will hopefully prevent a contractor from winning a bid without a firm grasp of what is required to successfully develop logistics support.

Post Contractor Award Analysis

We've looked at how a LLCC matrix can help identify optimum system designs, establish logistics "should cost" figures for funding and develop logistics support criteria for source selection. Once the contract has been awarded the detail and value of the matrix begin to grow. In a perfect world, nothing would change in a program from the time a contract was awarded until the system becomes operational. Since we live in a dynamic, ever changing world, program requirements change, technology advances and Murphy's Law takes its toll. A LLCC matrix can assist in evaluating change and its impact upon logistics support. It can

be used to conduct cost benefit analysis/trade studies and provide program logistics life cycle cost updates.

Through my involvement in military acquisition programs, I have discovered that cost benefit analysis/trade studies usually take only an optimistic, superficial look at the impact of a system change upon integrated logistics support. While few people will acknowledge it, cost benefit analysis/trade studies are generally conducted to justify pre-determined positions, usually for political reasons. Used properly, a LLCC matrix will force a pragmatic review of each logistics element to see whether it is effected, and if so, how much. While the answer may not be to the program manager's liking, it will at least identify those issues that have to be addressed eventually if that course of action is continued.

Once a system change has been approved, the LLCC matrix allows the total logistics cost figure to be updated. Again, this new figure, with supporting data, can be used to justify additional funding if required. As the program changes, the matrix is updated to reflect the change and its impact upon the logistics life cycle cost. The program manager should have an accurate picture, at all times, of his ILS program based upon the current system design being pursued.

CHAPTER IV

A LLCC MATRIX

Description

Figure 1. (3:3) shows how logistics life cycle cost fits into the total life cycle cost (LCC) picture. There are three general categories of expenses when computing the LCC of an acquisition program: (1) The RDT&E category which includes everything up to the Mile III decision; (2) the actual acquisition stage (Phase III) when the system goes into production and enters the field and; (3) the LLCC category (Phase IV) which includes the expenses to support the fielded system. There are of course some overlaps in these categories. For example, initial spares are usually bought with production money, not operating and support money. However, from an accounting stand point, they should be counted as a logistics cost, not a production expense. Also, logistics support analysis (LSA) occurs during all phases of the program but is most accurately categorized as a LLCC expense.

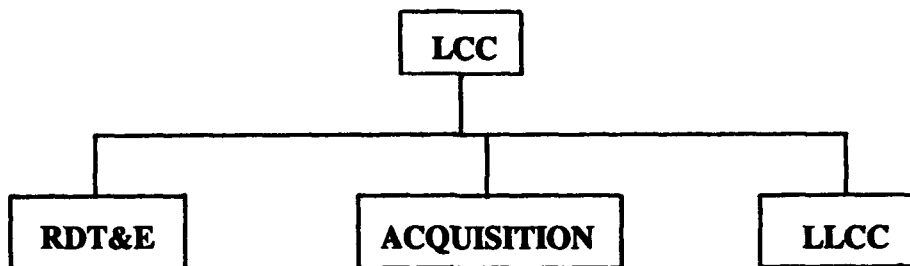


Figure 1. Life Cycle Cost (LCC) Major Categories

Figure 2. (3:3) gives a more detailed picture of the logistics elements that make up LLCC and how they support the total LCC program. As can be seen, there is certainly more to supporting a system acquisition program than first meets the eye. Because many of these elements are taken for granted, logistics issues and their related expenses are often overlooked. Software models or spreadsheets do exist, or can be easily developed, to project life cycle costs for each logistics element. Each element however, must be acknowledged at the beginning of the program and defined properly for that program to be of any real value. From my experience, this has been, and will continue to be, somewhat difficult to accomplish since funding is usually limited and contractor program managers are inherently reluctant to spend money on logistics issues until the system is ready to become operational.

The matrix that this paper describes has five categories of logistics life cycle cost.

They are:

- Logistics support analysis
- Initial support
- Operating and support
- Fuel, oil and lubricants
- Other.

Three of these categories, logistics support analysis, initial support and fuel, oil and lubricants will be described under Logistics Element Definition. The two remaining categories, operating and support and "other", will be explained below from the context in which they are used in this paper. Their sub-elements will also be discussed under Logistics Element Definition.

Operating and support costs (O&S) are maintenance labor and the consumed supply support elements of non initial spare and repair parts and expendable material. Initial spare and repair parts, and, fuel oil and lubricants, are placed in separate categories, not O&S to better isolate and identify their costs. This has benefits when comparing systems during source selection and when examining design changes after production has begun.

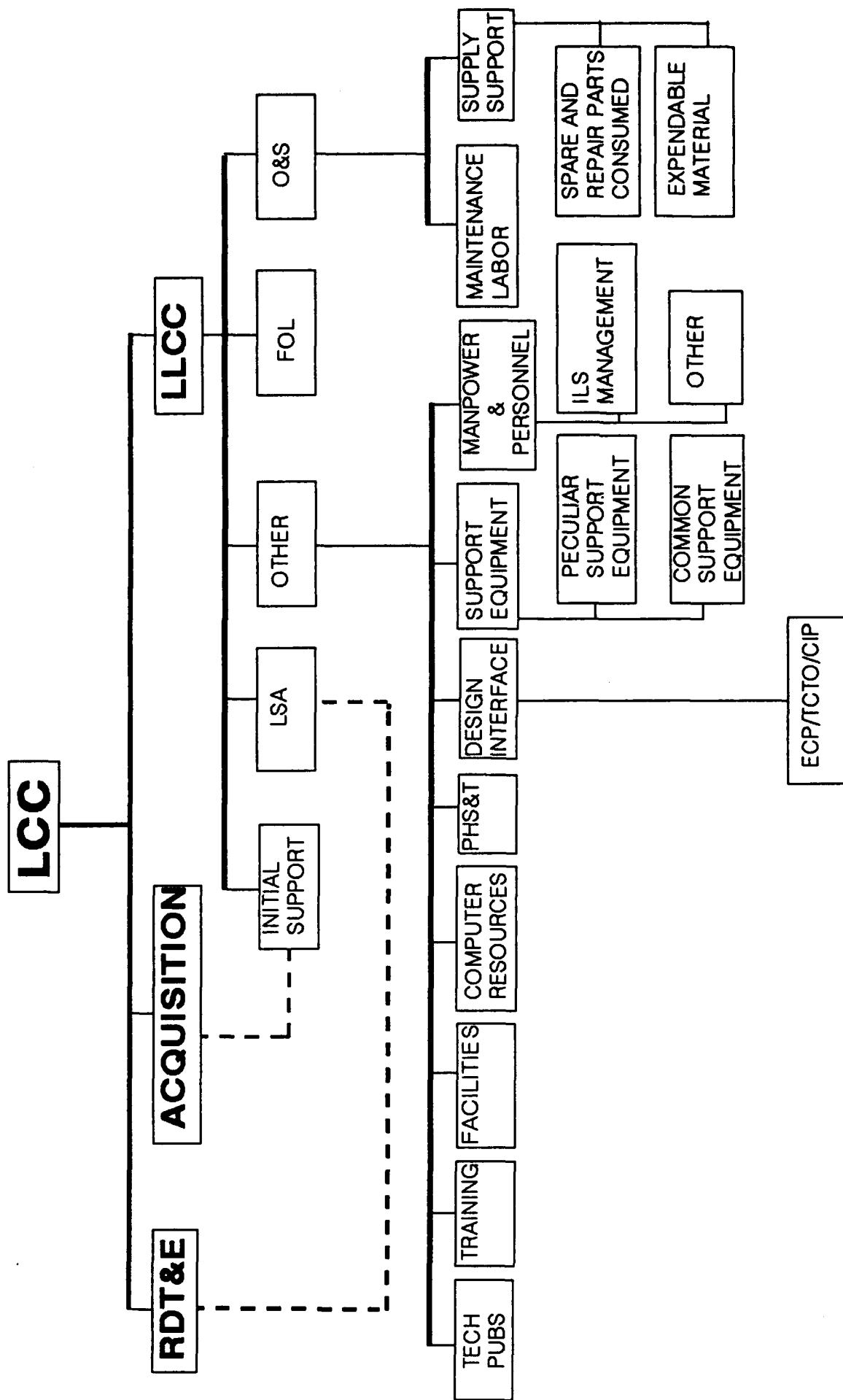


Figure 2. Logistics Life Cycle Cost (LLCC) Elements and LCC Integration

The "other" category combines the remaining logistics support elements that are most generally associated with integrated logistics support. They are:

- Technical Publications
- Training
- Facilities
- Computer Resources
- Packaging, Handling, Storage & Transportation
- Design Interface
- Support Equipment
- Manpower & Personnel.

Logistics Element Definition

The below listed major logistics elements, defined in general terms, make up the logistics life cycle cost portion of an acquisition program. Each element must be examined when computing the LLCC of a program. In the first phase of the program, LLCC projections are little more than educated estimates. With each new phase, more detail becomes available and increasingly accurate calculations are possible. The key to consistent estimates, at all stages of the program, is a realistic appraisal of each logistics element based upon its historical impact upon previous programs and its potential impact upon the current program. Required manpower and travel expenses must always be factored into the cost of a logistics element.

1. *Logistics Support Analysis* - Logistics support analysis is a detailed, comprehensive look at the logistics support resources necessary to support a system and its related support equipment. It's purpose is to identify design characteristics that will provide the customer with the best design while reducing the logistics life cycle cost of the system (5:3-1). Ideally, the LSA process should begin during the pre Milestone 0 activities and be staffed quickly and adequately to influence system definition during Phase 0 and Phase I of the system acquisition. Most of the costs for this effort will be funded during the RDT&E stage of the program.

After Milestone II, logistics support analysis should provide system analysis as required and updates to the logistics support analysis record (LSAR) throughout the life of the system (4:Chart). *A properly conducted logistics support analysis is the key to reducing logistics life cycle costs.* The LSA process significantly affects all of the other logistics elements. The program manager that recognizes this fact, funds the effort properly and ensures that adequate numbers of qualified personnel are assigned to the effort, will be well on the way to a successful program.

2. *Initial Support* - Initial support is that logistics support purchased by the customer with acquisition funding (3:3). The major contributors to this element normally include the initial spares and the logistics support portion of the Production Engineering Support (PES). Initial support is funded out of production money and not support money but is considered part of logistics life cycle cost, therefore, it is shown as a dotted line to acquisition and a solid line to LLCC in Figure 2. Computing initial support costs separately allows the forecasting of appropriate budgetary estimates.

3. *Technical Publications* - The purpose of this element is to produce technical publications that enable the customer to operate and maintain a system at the peak of its capability with minimum logistics life cycle cost (5:8-1). The publications will be based upon the approved LSA data base with enhancements as necessary. Technical publications support involves contractor and government (acquisition and end user) personnel in the development of technical data, the production of publications and the coordination of periodic reviews to determine requirements for revision.

4. *Training* - This element defines the requirements for personnel, training and training equipment for the system (5:7-1). It includes contractor and government personnel requirements in the development and production of training documentation and equipment, the establishment of a contractor or customer operated training program, the training of trainers and the periodic update of training materials. The training program will be based upon the

logistics support analysis of the system and the technical publications produced to support the system.

5. *Facilities* - The facilities element describes the approach for defining, developing and implementing a facilities program to support the production system. Those site requirements and functions are generally identified as: operational facilities, maintenance training, depot and mobile maintenance facilities. All maintenance facility planning for the identified site requirements will be based upon, and traceable to, data provided in the logistics support analysis (5:11-1).

6. *Packaging, Handling, Storage and Transportation* - Packaging, handling, storage and transportation (PHS&T) requirements have a greater impact upon the operational aspects of a program than the costs would imply. All requirements must be identified and accounted for early in the program. Integration of the PHS&T element with the LSA/LSAR is of primary importance in carrying this out. The LSAR must be used as the basis for all associated data elements to ensure that the information contained in PHS&T related records is at all times consistent with the balance of the LSAR (5:12-1). A component's reliability can be greatly influenced by the manner in which it is packaged, the type of handling equipment and procedures that are used, where and how it is stored, and the mode of transportation used to move it from one location to another (1:3-R-5).

7. *Computer Resources* - The purpose of this element is to identify the facilities, hardware, software, documentation, manpower, and personnel required to operate and support mission critical computer hardware/software systems. The difficult part of dealing with this element is finding a funding "home" for these resources because it does cross the lines of responsibility into other ILS elements. It is important that this element be coordinated by a single computer resources manager (1:3-R-4). A thorough review, acknowledgment and funding of computer resource requirements by the program manager up front can prevent the cost overrun drills generated by unbudgeted computer resource acquisition.

8. *Support Equipment* - This element encompasses the costs associated with the selection, design, procurement and support of support equipment. The objectives of this effort are to: (1) maximize the utilization of common support equipment and; (2) minimize the requirement for peculiar support equipment. This must be accomplished by enhancing the operability/supportability/durability of the system while minimizing the support personnel and skill level requirements. The logistics support analysis process and the logistics support analysis record are important factors that must be taken into consideration when identifying support equipment needs (5:9-1).

9. *Manpower & Personnel* - The manpower and personnel element covers personnel not included when determining requirements and computing costs for the other logistics elements. It generally includes integrated logistics support management, administrative and "other" people not easily placed in other elements. Maintenance labor requirements could easily be identified under the manpower and personnel element but, for the purposes of this paper, are categorized as a logistics life cycle cost under operations and support.

10. *Supply Support* - Supply support consists of the spare and repair parts and expendable material used to support a system's maintenance effort. Integration with the logistics support analysis process and the logistics support analysis record is of primary importance when computing supply support requirements and costs. The LSAR is used as the basis for all associated data elements to ensure that the information contained in the appropriate data records is, at all times, consistent with the balance of the LSAR. Accurate reliability projections are certainly an important aspect when determining spare and repair part requirements. Unjustified optimism, with respect to the reliability of a system and its components, can leave a program short in spare and repair parts and funding in the supply support arena (5:10-1).

11. *Design Interface* - This involves the relationship and impact of logistics-related design parameters to readiness and support resource requirements (1:3-R-5). Logistics life cycle design interface costs also involve the logistics support of Engineering Change Proposals

(ECP), Time Compliance Technical Orders (TCTO), Component Improvement Programs (CIP), etc. It must be remembered that any of the design interface efforts will impact many, if not all, of the logistics elements listed under the "Other" category in Figure 2. Support requirements for these efforts may last throughout the life of the system and must be identified early and accurately to ensure that adequate funding is made available.

12. *Fuel, Oil and Lubricants* - Fuel, oil and lubricants (FOL) have historically made up a large portion of the logistics life cycle cost of any system when petroleum was the primary source of energy. Now that alternative sources of energy are available like natural gas, nuclear, or solar this may or may not be true. Additionally, if electricity is the primary fuel used by the system, other questions arise. Is it purchased from an independent source (electric utility) or produced from one of the above mentioned energy sources as part of a self contained energy program? FOL considerations such as source, availability, dependability and cost are significant LLCC drivers that cannot be ignored.

Program Comparisons Using a LLCC Matrix

A logistics life cycle cost matrix can have value at any stage of a program as discussed earlier. From the customer program manager's perspective, however, a matrix can have a significant impact upon a program during the source selection phase of a competitive program. Accurate LLCC projections can, and should, influence the selection of a production system if the logistics cost of one system is identified as reducing the overall life cycle cost of that system when compared to another. It is, of course, during the source selection phase that the data used in long range forecasting is the least accurate. Depending upon the accuracy and detail of the software models used for each logistics element, the assumptions used in defining the boundaries of the element and whether a realistic vice optimistic view of the element requirements is taken, the LLCC matrix can provide a very good or a very poor forecast.

One way to demonstrate the importance of the logistics life cycle cost matrix is to look at two programs involved in a source selection process. The numbers for Program A were

taken from an actual aircraft engine program while the numbers for Program B were generated to demonstrate how the LLCC matrix can be used. The programs will be compared with respect to the impact of logistics life cycle cost on the life cycle cost of each program over a 20 year period. The programs will be major aircraft engine programs involved in a competition for a new aircraft. The following assumptions will be used when comparing the two programs:

1. Both programs received the same amount of RDT&E funding through Milestone II.
2. Both programs meet the minimum requirements of the specification.
3. The Program B engine attained reliability, maintainability and supportability (RM&S) figures 30% better than Program A.
4. The Program B engine has a specific fuel consumption (SFC) 10% less than the Program A engine.
5. The winning engine will be determined at Milestone II.

Each program will be discussed below with the emphasis being upon the differences between Program A and Program B. The life cycle cost matrix covers only 20 years for the sake of simplicity. A real engine program would probably last longer with the end of service date not defined.

As can be seen from the matrix in Figure 3. (3:10), the percent make up of the major categories in the LCC matrix for Program A is: RDT&E, 2.56%; Acquisition, 23.94 % and ; Logistics Life Cycle Cost 73.5%. When seen from this perspective, it's obvious to the program manager how important it is to minimize the logistics cost of a program. Almost three quarters of the total program cost is support related, with fuel being over half the program cost. These percentages are representative of a major aircraft engine program. Other systems, big or small, will have unique percentage profiles based upon the system type. It should be remembered that the logistics elements will almost always be the same, regardless of system type.

Program A

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total	% of Total
RDT&E	\$24,860	\$38,170	\$35,970	\$1,300	\$1,300	\$900	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$102,560	2.56%
Acquisition				40,396	64,844	82,214	118,610	119,462	120,844	118,960	79,480	72,836	70,466	59,770							967,862	23.94%
Logistics Life Cycle Cost	1,269	8,446	32,863	49,203	46,468	83,980	118,140	143,939	164,691	183,243	185,957	190,817	196,731	203,097	211,740	221,920	222,479	223,732	224,558	225,716	2,940,808	73.50%
LSA	1,269	8,356	8,300	2,644	748	653	546	540	487	465	457	420	420	420	240	240	240	240	240	240	27,187	0.86%
Initial Support				6,243	6,538	16,650	17,299	16,488	16,249	15,286	10,477	8,450	7,364	5,736							128,981	3.17%
Operations & Support				7,577	10,987	14,415	18,013	20,024	20,998	19,950	14,924	14,503	14,248	13,025	16,653	19,581	20,302	21,063	23,048	24,333	294,544	7.36%
Supply Support				4,364	7,011	10,117	13,134	14,204	14,875	13,608	8,468	7,628	7,314	5,776	9,164	11,627	11,624	13,293	14,062	14,844	181,413	4.53%
Spare & Repair Parts				4,039	6,484	9,221	11,861	12,816	13,452	12,297	7,634	6,924	6,634	5,213	8,324	10,487	10,487	11,845	12,563	13,346	163,667	4.05%
Expendable Material				325	527	696	1,273	1,368	1,423	1,311	634	704	680	563	640	1,140	1,437	1,448	1,469	1,468	17,756	0.44%
Maintenance Labor				3,213	3,976	4,296	4,879	5,820	6,123	6,342	6,456	6,875	6,934	7,249	7,486	7,934	8,378	8,660	8,966	9,469	113,131	2.83%
FOL				6,850	11,456	34,377	62,839	83,500	113,956	134,569	147,359	154,864	163,897	171,515	182,843	190,245	190,245	190,245	190,245	190,245	2,228,072	55.71%
Other	90	24,383	25,889	16,736	17,665	19,441	13,387	13,001	12,953	12,740	12,580	12,802	12,401	12,204	11,874	11,874	11,862	11,264	11,025	10,868	283,025	6.57%
Technical Publications				16,050	9,591	2,453	1,680	1,514	1,496	1,387	1,344	1,278	1,165	1,045	966	860	816	823	512	438	44,216	1.11%
Training				5,524	423	446	475	521	553	569	600	634	668	694	716	734	712	694	600	600	15,783	0.39%
Facilities				2,000	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	5,000	5,000	5,000	5,000	5,000	5,000	64,500	1.61%
Computer Resources				50	62	110	137	160	180	230	300	330	350	370	390	395	330	330	330	330	4,704	0.12%
PH&T				50	110	210	310	410	510	610	700	790	880	960	1,034	1,104	1,165	1,232	1,286	1,317	13,681	0.34%
Design Interface				6,032	6,913	9,140	10,727	4,568	4,012	3,456	2,934	2,413	2,165	1,895	1,663	1,436	1,253	1,197	1,012	931	61,797	1.54%
Support Equipment	90			8,408	4,859	3,678	3,509	2,980	2,573	2,453	2,174	2,004	1,948	1,834	1,802	1,802	1,802	1,802	1,802	1,802	47,388	1.18%
Manpower & Personnel				640	745	745	745	800	800	800	800	800	800	800	800	800	800	800	800	800	10,915	0.27%
TOTAL	\$26,149	\$46,616	\$68,653	\$90,696	\$112,612	\$177,074	\$236,750	\$283,401	\$285,535	\$302,203	\$286,437	\$283,653	\$286,197	\$282,867	\$211,740	\$221,920	\$222,479	\$223,732	\$224,558	\$225,716	\$4,981,191	100.00%

Figure 3. Program A Life Cycle Costs

Representative prices are in fixed year dollars (Thousands of Dollars)

The matrix in Figure 4. shows the life cycle cost figures for Program B. The percent of total figures for Program B are: RDT&E, 2.80%; Acquisition, 27.98% and; Logistics Life Cycle Cost, 69.22%. The first major life cycle cost category in Program B, RDT&E, shows a larger percent of total cost even though the absolute cost is the same as Program A. This is, of course, because the acquisition and logistics life cycle cost percentages have changed. For the purposes of this analysis, it has no affect on either of the other two major categories and will be ignored.

When the program manager begins to compare the acquisition costs of the two programs, Program B has absolute costs of about \$67 million more, and a percent of total of about 4% more, than Program A over the entire acquisition cycle. Company B has designed a higher quality engine with improved reliability, maintainability and supportability features, but which costs more to manufacture. If the program manager stops his analysis here, and ignores the logistics life cycle cost category, he will, most likely, choose Program A because of the short term political and fiscal pressures from his service, DOD, Congress or the Administration. Regrettably, the near term bottom line may take precedent since acquisition must be addressed immediately while long term support can be dealt with on somebody else's "watch."

If the program manager looks further, he/she now sees some good news when he/she looks at the logistics life cycle cost of Program B and sees that the percent of total is more than 4% less than Program A. In the review of the LLCC category, the program manager now notices that Company B has spent more up front money on logistics support analysis. Company B has chosen to spend additional money on LSA in order to translate its design, reliability, maintainability and supportability advantages into reduced logistics costs. As was stated earlier, the return on investment of a properly conducted LSA program, can be many fold over the initial expenditures in reducing support costs. This becomes apparent as initial support is looked at in Program B.

Program B

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total	% of Total	
RDT&E	\$24,860	\$38,170	\$35,970	\$1,300	\$1,300	\$900															\$0	\$102,500	2.80%
Acquisition				43,224	66,363	98,669	126,913	127,824	129,303	127,267	85,044	77,935	75,399	63,954								1,024,934	27.96%
Logistics Life Cycle Cost	1,367	8,665	30,873	39,758	38,035	66,362	98,063	120,342	138,999	158,171	160,464	165,739	173,122	177,698	185,916	194,513	194,823	195,961	196,247	197,043	2,535,971	69.22%	
LSA	1,397	8,632	9,374	3,542	658	420	420	420	420	420	420	420	420	420	240	240	240	240	240	240	29,023	0.79%	
Initial Support				4,370	4,577	11,795	12,109	11,541	11,374	10,700	7,334	5,915	5,155	4,015							66,665	2.43%	
Operations & Support				5,304	7,691	10,090	12,609	14,048	14,699	13,985	10,258	10,152	9,974	9,117	11,657	13,693	14,211	15,388	16,134	17,033	206,023	5.82%	
Supply Support				3,055	4,908	7,061	9,194	9,974	10,413	9,526	5,739	5,340	5,120	4,043	6,415	8,139	8,347	9,305	9,843	10,361	126,831	3.46%	
Spare & Repair Parts				2,827	4,539	6,454	8,303	9,003	9,416	8,808	5,155	4,847	4,644	3,649	5,827	7,341	7,341	8,292	8,915	9,342	114,402	3.12%	
Expendable Material				228	369	627	891	972	996	918	564	493	476	394	588	798	1,008	1,014	1,028	1,049	12,429	0.34%	
Maintenance Labor				2,249	2,763	3,009	3,415	4,074	4,266	4,439	4,519	4,813	4,854	5,074	5,242	5,554	5,865	6,063	6,290	6,642	79,182	2.16%	
FOL				6,165	10,312	30,939	56,555	84,150	102,560	121,130	132,823	139,376	147,507	154,364	164,379	171,221	171,221	171,221	171,221	171,221	2,008,167	54.76%	
Other																							
Technical Publications	63	21,499	20,377	12,598	13,118	14,370	10,183	9,946	9,946	9,656	9,849	9,874	10,066	9,762	9,641	9,360	9,151	8,942	8,653	8,549	205,873	5.82%	
Training				14,445	8,632	2,208	1,512	1,363	1,346	1,248	1,210	1,049	941	887	851	801	736	561	461	394	39,794	1.09%	
Facilities				4,695	360	379	404	443	470	501	510	539	568	590	624	590	510	510	510	510	13,320	0.36%	
Computer Resources				1,600	400	800	1,200	1,600	2,000	2,400	2,800	3,600	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	51,600	1.41%	
PH&SAT				35	57	77	67	112	126	161	210	231	350	370	390	395	330	330	330	330	4,232	0.12%	
Design Interface				35	77	147	217	287	357	427	490	553	616	672	686	724	773	837	902	922	9,564	0.26%	
Support Equipment				4,222	4,839	6,398	7,509	3,198	2,608	2,419	2,054	1,689	1,530	1,327	1,185	1,005	877	838	708	652	43,258	1.18%	
Manpower & Personnel	63	48	5,864	3,401	2,575	2,458	2,086	1,801	1,717	1,522	1,403	1,364	1,264	1,261	1,261	1,261	1,261	1,261	1,261	1,261	33,170	0.91%	
				640	745	745	600	600	600	600	600	600	600	600	600	600	600	600	480	480	480	10,915	0.30%
TOTAL	\$26,257	\$46,865	\$69,843	\$84,282	\$106,718	\$165,931	\$222,976	\$248,167	\$269,303	\$283,456	\$245,527	\$243,673	\$249,520	\$241,652	\$185,916	\$194,513	\$194,823	\$195,961	\$196,247	\$197,043	\$3,893,404	100.00%	

Figure 4. Program B Life Cycle Costs

Representative prices are in fixed year dollars (Thousands of Dollars)

Company B has been able to translate its 30% improvement in reliability into a direct 30% reduction in initial support costs. Interestingly enough, the savings in initial support alone is around \$38 million. This is a savings of over half the additional amount spent during the acquisition process. While the exact percentage in a real program might be open to debate, the point is that an improvement in reliability will reduce the number of system failures and, therefore, reduce the number of initial spares that are required to support the engine.

Under the operations and support element, the same logic is applied to supply support and maintenance labor. For the sake of consistent analysis, the improved reliability also translates to a 30% reduction in the spare and repair parts and expendable material required. The improvement in maintainability and supportability also translated to a 30% reduction in maintenance labor over the life of the engine. The improvement will not be quite as noticeable at the unit level as it will at the other levels, especially depot, since the more expensive repairs are accomplished at other than the unit level. RM&S improvements amplify the savings at the depot level since fewer shop visits are required and, therefore, less maintenance labor is needed. The projected savings in O&S in Program B are about \$88 million. This exceeds the *entire* increased cost in acquisition for Program B.

The largest LLCC element for an aircraft engine is the fuel, oil and lubricants element. Through improved design characteristics, Company B was able to reduce its projected specific fuel consumption by 10%. Over a 20 year period, this would result in a savings of approximately \$223 million in FOL costs--not an insignificant figure.

The "other" LLCC element is certainly the most neglected one of the group. The military customer almost always finds funding for O&S and FOL since those elements keep the aircraft flying and operational. However, based upon my experience, inside and outside of the government, the sub-elements of "other" are many times inadequately addressed and funded with insufficient monies. Both the government and the contractor assume the cost of these logistics elements will be low because they both *want* them to be low. When both sides discover that these costs are not low, there is much gnashing of teeth and wringing of hands.

Through the LSA process, Company B was able to reduce the costs of technical publications 10% and training 15%. Both of these sub-elements are highly dependent upon a proper LSA being conducted to keep costs low. The cost of facilities was projected to be reduced by 20%. This figure was based primarily upon the number and size of depot facilities required to support the engine. Reduced maintenance requirements at the base level also allowed for some sharing of maintenance facilities which reduced unit facility costs. Computer resource costs were projected as being identical with Program A since the number of total units would still be the same with either program. PHS&T, design interface and support equipment costs are estimated to be 30% less than Program A because of the design and RM&S improvements which reduce the requirements in each of these sub-elements. Lastly, the manpower and personnel sub-element in Program B remains the same as Program A since the number of ILS management and other required, but not easily categorized, people remains low.

When "other" is totaled, a savings of almost \$58 million is achieved in this category in Program B over the same category in Program A. This brings the total logistics life cycle cost savings of Program B to \$405 million over Program A. Once the additional acquisition cost is subtracted out of the Program B savings, the total life cycle cost savings is \$338 million. The program manger who looks at the total life cycle cost picture will see that the logistics life cycle cost savings in Program B make that program a better choice on just price alone. When the benefits of a better design are figured in, Program B is the obvious choice for production.

CHAPTER V

SUMMARY

A logistics life cycle cost matrix for a system is important to both the customer and the vendor when the price of integrated logistics support is being computed. It provides a systematic approach to estimating the cost of a fielded system for: (1) pre contract award analysis; (2) establishing criteria for source selection; (3) cost benefit analysis/trade study evaluations and; (4) post contractor award analysis.

This guide provides a program manager with a broad overview of the factors that must be considered when estimating system integrated logistics support costs and a framework within which to compute them. Logistics is now receiving more attention at the beginning of a program than it has in the past. But, being identified as an important part of a program *and* being treated as important part of a program may be two different things. If a credible method of estimating logistics costs can be found, then the customer and the program managers involved will have confidence that what they are being told is true. Hopefully, this discussion of logistics life cycle costs and the LLCC matrix will go a long way towards providing all concerned with at least one workable method for estimating a system's logistics costs.

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