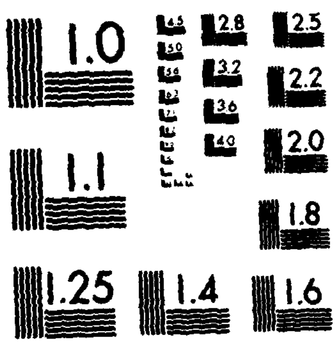
AD-A171 914 LOGISTICS SUPPORT ANALYSIS IN LIFE CYCLE COST MANAGEMENT(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYSTEMS AND LOGISTICS R D KANKEY 1/1

UNCLASSIFIED 18 AUG 86 AU/AFIT/LSQ-86-1 F/G 15/5 NL



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LOGISTICS SUPPORT ANALYSIS
IN
LIFE CYCLE COST MANAGEMENT

TECHNICAL REPORT

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AU-AFIT-LSQ-86-1

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ABSTRACT

Life Cycle Cost and Life Cycle Cost Management opened another dimension of complexity for DoD managers. Logistics Support Analysis is seen by some as a competing subject. This literature review considers life cycle cost, logistics support analysis, and integrated logistics support. Conclusions are that logistics support analysis is a proper subset of integrated logistics support, while integrated logistics support is a proper subset of life cycle cost management.

Further research is needed to verify the cost effectiveness of logistics support analysis. If data cannot be gathered for a proper statistical analysis, then more case studies such as the SINCGARS (1975) study need to be performed.

LOGISTICS SUPPORT ANALYSIS
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Roland D. Kankey

18 Aug 86

INTRODUCTION:

A few years ago the concept of Life Cycle Cost (LCC) opened another dimension for DoD managers. The need to consider total costs, acquisition and ownership, prompted studies, directives, regulations, courses, articles and books. Since then Life Cycle Cost (LCC) has been "institutionalized" to the point where one systems command OPR indicated more interest in Logistics Support Analysis (LSA) then in Life Cycle Cost Management.

How did this occur? One likely reason is the shift in perceived meaning of LCCM over time. The objective was origionally perceived as striving for the lowest total cost to get the job done. Then the emphasis shifted to stressing a search for the best balance of performance, schedule, and cost. A later shift added the criterion of supportability into the balance. One could argue that each of these shifts was actually only a clarification of the origional intent of LCCM, but such shifts in perception can weaken the image of a management philosophy.

A true believer in life cycle cost management would view LSA as a procedure for helping achieve several of the objectives of an LCC program. But even the true believer would want to know more about this interloper called Logistics Support Analysis.

WHAT IS LCCM?

The life cycle cost of an item or system is the total cost of development, acquisition, ownership and disposal directly associated with or due to the item. The item can range in size from a computer chip to a weapon system. LCCM requires the estimation of LCC for alternative items before decisions are made on the alternatives. We cannot avoid it for lack of alternatives since, given the right viewpoint, all decisions have alternatives, even if one is to do nothing at all.

LCCM thus levies a requirement to estimate these alternative costs with a concurrent search for guidelines and data. We must consider these costs, with their inherent uncertainties, as a factor when trying to select the optimum alternative; the one with the best combination of benefits and cost. If the alternatives can be adjusted to a common mission accomplishment or effectiveness level and schedule, i.e., we are in an equal benefit position, then the optimal or best alternative can be selected based on life cycle costs and the outlay patterns. However, if they cannot be adjusted to a common effectiveness level, i.e. we are in an unequal cost, unequal benefit position, the guidelines require use of economic analysis techniques.

In a more general context, every decision which results in use of limited resources should consider total costs. Almost all of us make tnese types of decisions not only on a professional but on a personal level as well. The concept is often applied when we make decisions as to which house to buy, which appliances to buy, or ever how fast to drive.

MANAGING A LCCM PROGRAM

Although trying to manage a LCCM program is a very complex task, several of the primary concerns can be summarized by considering the seven precepts reiterated in this section. [Kankey, 1982] In 1975 the Deputy Secretary of Defense acknowledged that the primary cost considerations associated historically with decisions to develop, buy, and operate a new system were the research, development, and production (acquisition) cost (Clements, 1975). The manager and others concerned with life cycle costing must first overcome this interia. "We have always done it this way." "Don't rock the boat." "That's their problem!" Such phrases indicate interia. Organizations and people are more comfortable doing things in ways that have been "successful" in previous programs. There is a built in resistance to change. This interia is changed only by exerting a superior force. This force comes from clear management signals that previous patterns must be changed; that previous ways were not totally "successful". A corollary to this effort, which will help reduce the interia, is to inform and educate all those personnel who will be dealing with the program about the goals of LCCM. As a good map helps reduce one's reluctance to move into unknown territory; education on life cycle costing will reduce interia.

A second precept is to develop a questioning approach. Given the situation of limited resources the manager must consciously struggle to determine firm requirements for each performance, cost, schedule, and supportability parameter. In general, all of these parameters must be tradeable with the others. The only way to determine the requirements and how they can be traded is to ask questions. Assuming a requirement is firm precludes some of the trades or alternatives that should be considered.

A third precept is to do the quantitative homework. The use of cost as a tradeable item of generally equal importance with performance, schedule, and supportability requires that adequate estimates and usually models be developed that include the major and important cost drivers and design parameters. Decisions based on subjective opinion may be right or wrong, but they should be supported by analysis if they are to be given weight in the decision process.

A fourth precept is to iterate the design. One of the foundations of life cycle cost is that decisions made during the system or item design will impact the cost of production and of ownership. The designer needs feedback as to the expected cost of the proposed design, as well as a breakout of the cost elements. This allows design effort to be focused on the high cost elements. This means that a LCCM program would probably need slightly more time during the design phase.

The fifth precept is to trade-off performance, schedule, cost, and supportability parameters. This is not to imply that any of these parameters can be ignored. But Kirkpatrick and Pugh (1985) point out that a sad fact of fiscal life is that total force effectiveness may be decreased by trying to pack too many requirements, or too much capability into each unit. Reducing the desire for the highest unit capabilities is a very difficult task since there is always the hope that additional resources will be found. There need not be any question as to whether the initial requirements would be important, but rather whether all can be achieved, and if so what the effect would be on the total force.

The sixth precept recognizes that any program requires teamwork between the government who needs the item, and the contractor who delivers it. This desire to assure contractor commitment is critical. If the contractor who does the work is not interested in providing a system or an item with good life cycle cost characteristics, the customer will probably not get one. Similarly, if one asks for 500 hours mean time between failure on a development project, the contractor has no reason to expend extra effort and resources to achieve 1000 hours mean time between failure. The teamwork generally requires some sort of contractually binding procedure that rewards the contractor for good LCC, yet weakens future business prospects for bad LCC characteristics. As found by Baumgartner, Brown, and Kelly (1984), clear communication between the Program Office and the Contractor is important for program success.

The seventh and last precept is to assure user commitment. Since the user is generally the requiring organization, it is most important that they be continually involved throughout the acquisition process. Failure to keep them involved will weaken their acceptance of the product and reduce their willingness to follow through on the changes required to achieve the estimated cost levels. Massey (1973) discussed the need for likages that would reduce the largely allocated ownership costs as LCC decisions are made. Maintaining user commitment would be essential if these linkages are to work.

While adherence to the above precepts should help assure that an acquisition program would have good LCC characteristics, many of the details are left out. To consider some of these details the rest of this paper reviews Logistics Support Analysis and Integrated Logistics Support, and attempts to compare them to LCCM.

WHAT IS LOGISTICS SUPPORT ANALYSIS?

> LSA is defined as: The selective application of scientific and engineering efforts undertaken during the acquisition process, as part of the system engineering and design process, to assist in complying with supportability and other ILS objectives.
>
> MIL-STD-1388-1A, LSA

It is thus a part of the system engineering and design process, as is reliability and maintainability. It is seen as a major vehicle for incorporating logistics considerations in system design. (Hull and Lockhart, 1982)

WHY LSA?

But surely the general notion of balancing performance, schedule, cost and supportability would be sufficient! Apparently not. Deputy Undersecretary of Defense Long (1981) indicated in a task force report that "there has not been a substantial shift in traditional priorities"; meaning that cost, schedule, and performance objectives were treated as superior to support and readiness objectives. Accepting this at face value indicates that the efforts in the 1970's to elevate cost to a position equal in importance with performance and schedule was successful. The thrust for the eighties is apparently to achieve the same for supportability. LSA and ILS are tools for the accomplishment of this objective. Proper application of these tools will help assure a good LCCM program, by aiding in identification of logistics opportunities, generally leading to better readiness, supportability, and cost characteristics for the overall system.

HISTORY OF LSA

The concept of LSA was published in MIL-STD 1388-1, Logistics Support Analysis, and MIL-STD 1388-2, Logistics Support Analysis Record, October 1973. The intent was to advance the services' methods for dealing with logistics planning. However, it soon became apparent that there were some areas where the standards needed to be improved. In particular the following points have been cited about the original standard.

- 0 Some of the thirteen task paragraphs were unachievable.
- 0 The sample data sheets allowed each service or project to develop their own data formats.
- 0 Users were allowed to redefine, delete, and add to the data elements in the standards.
- 0 The standards were difficult to tailor.
- 0 There were no Data Item Descriptions (DID's) that could be used to obtain the results of the analysis.

Due to these recognized problems, a Joint Service LSA Working Group was established in 1979 to update these standards. The revised MIL-STD- 1388-1A was published in April 1983. The updated MIL-STD 1388-2A was published in July 1984. (Peer)

These revisions were a major step in the DOD drive to emphasize peacetime readiness, wartime sustainability, and supportability considerations in the requirements process. The old LSA concept tended to view LSA as a post-design effort to be picked up in full scale development and dropped upon the conclusion of production. The new standards call for LSA to be considered in the design process and all the way through deployment. (Biedenbender)

THE LSA CONCEPT

The basic idea behind LSA is that proper planning for logistics supportability will result in weapon systems and equipment which can be supported when fielded. There are clearly two aspects to this supportability. First, the LSA process helps assure a system or equipment with good supportability characteristics. This is started with the tasks in what is called "Mission and Support Systems Definition". During this portion of LSA:

0 Pertinent supportability factors such as mobility requirements, mission frequency and duration, and operational requirements are identified and documented.

0 Field visits are made to operational units most similar to those expected for the new system.

0 Information for the standardization program is developed and provided.

0 Design opportunities due to technology improvements which could improve supportability are identified and evaluated.

0 Quantitative supportability and supportability related design objectives, goals, thresholds, and constraints for the new system are established.

During the next major set of tasks the alternative system possibilities are considered, with trade-offs including the support system alternatives. This then leads to a best combination of system/equipment and support alternative.

The second aspect of the LSA process is to assure that the ability to support the system will be available when needed. Parts of this are done concurrently with the first. For example one task within "Mission and Support System Definition" was to identify existing and already planned support resources that would be useful for the new proposed system or equipment. These of course enter into the various trade-off studies. Once an alternative is chosen the series of tasks under the section "Determination of Logistics Support Resource Requirements" is intended to assure that logistics requirements are properly identified in terms of quantities and costs.

It is clear that both aspects of LSA will lead toward higher readiness, and higher sustainability. The first aspect helps assure more intrinsic supportability; the second aspect helps assure the facilities, trained personnel, support equipment, spares, and repair parts are available when needed. LSA should thus be of considerable interest to the commanders of AFLC and the operating commands who are concerned with maintaining forces ready for war, and to the commanders of the joint and unified commands who are responsible for fighting such wars.

<u>ILS vs LSA</u>

Integrated Logistics Support is defined as "... a composite of all the support considerations necessary to assure the effective and economical support of a system for its life cycle. It is an integral part of all other aspects of system acquisition and operation." (DODD 4100.35, 1 Oct 1970).

Another source relates ILS and LSA by stating that the objective of LSA is to "systematically pull together all the engineering functions that contributed to the design, development, and deployment of an integrated logistics system." (AFLC/AFSC P 800.34). The objective of ILS is variously stated by Carson (1960) as:

0 To increase cost effectiveness and mission readiness of system and equipment support.

0 To eliminate support requirements whenever practical, and reduce those remaining support costs to the optimum level consistent with operational readiness requirements.

0 To develop systems and equipments into configurations that are inherently supportable.

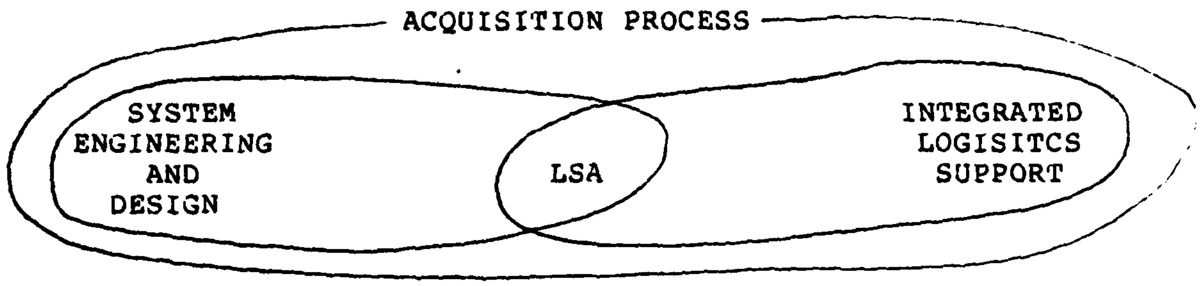
Carson indicated this was done through comprehensive planning (management, administrative, and technical) and thorough evaluation of prime equipment/support trade-offs throughout the life cycle. Another government source refers to ILS as the life cycle task of support management. Responsibility is said to be preservation of continuity in the systematic planning, development, acquisition, and operation of weapons and equipment in order to maximize readiness and optimize cost. (4100.35 G)

The latest listing of ILS elements is:

0 Maintenance Planning
0 Manpower and Personnel
0 Supply Support
0 Technical Data
0 Training and Training Support
0 Computer resources support
0 Facilities
0 Packaging, Handling, Storage, and Transportation
(DODD 5000.39, 1983)

Now since MIL-STD 1388-1A indicates that LSA is part of the ILS program, and also that LSA is an integral part of the system engineering process (which is not an ILS element) there is naturally some confusion on how these programs relate.

It would appear that the relationship could be expressed pictorially as:



That LSA is key to ILS is supported in MIL-STD 1388-1A. The Use Study, the first step toward defining mission and support systems (which includes field visits), is the prerequisite analysis task to all others in the LSA program. It also provides the basis for all ILS planning and readiness analyses for the new system.

An alternate view by Craig (1986) is that ILS itself is a subset of the System Engineering process. While his definition of the system engineering process refers to production and fielding of all operational and support system elements, the definition of systems engineering he quotes from Army Field Manual 770-78 and the definition from the Compendium of Authenticated Systems and Logistics Terms, Definitions and Acronyms (1981) do not appear to support this view. Craig does support that LSA is a subset of ILS and of design, with design a clear subset of system engineering.

LCCM vs LSA

Life Cycle Cost Management is the title developed for the concept of balancing the conflicting desires for high performance, low cost, and excellent supportability; as well as schedule constraints. Since so much has been included in the concept some will claim that it is now mistitled, that the stress on cost causes LCCM to be misunderstood. Back in the 1960's and early 1970's when this concept was under initial test, the consideration of life cycle cost as a critical item in a system's or equipment's development was a significant break from "If they all meet the contract specifications, buy the cheapest." Several examples with hydraulic filters, aircraft tires, and radios indicated the value of the "life cycle cost" approach.

A common question when two concepts/programs with somewhat similar aims are developed is "can the newer replace the older", or in this case "can LSA replace LCCM?" To evaluate this question one should look at the scope of each. Good LCCM requires that all requirements from "Do we need 10 watts output?" to "Is soft field capability necessary?" be considered. It is essentially open ended as to what aspects of the program can/should be questioned. Only items that do not affect performance, schedule, cost, or supportability can be ignored. Even items outside the program manager's control should be considered, evaluated, and brought to the attention of those who do have the control. The tendency to assume that those who levy the "requirements" fully grasp the performance, schedule, cost and supportability impacts must be quelled. The LCC Manager must not limit the horizon of concern to only costs, but rather must consider all the elements discussed in DODD 4245.3, Design to Cost.

In contrast LSA is defined as part of the system engineering and design process, and LSAR is defined as the portion of LSA documentation consisting of detailed data pertaining to identification of logistics support resource requirements of a system/equipment. The first task of LSA has as inputs:

- 0 Expected mission and functional requirements for the new system/equipment.

- 0 Expected program funding and schedule constraints.

It is thus apparent that many of the pertinent LCCM questions will not be asked in LSA. The scope is more limited from the start. The principle aim is to comply with the supportability objective of ILS. As such, LSA is a critical part of LCCM, but definitely only a part.

ILS vs LCCM

Since LSA is an important part of LCCM and of ILS, is it possible that the latter two are pseudonyms? Does having a good ILS program mean you have a good LCCM program? Again the two are closely aligned but lets take another look at a different definition of ILS:

... a disciplined approach to the activities necessary to

- 0 Cause support consideration to be integrated into system and equipment design.

- 0 Develop support requirements that are consistently related to design and to each other.

- 0 Acquire the required support.

- 0 Provide the required support during the operational phase at minimum cost.

(MIL-STD 1388-1A)

Although ILS clearly involves more that LSA, the questioning of needs and operational requirements is not mentioned. The balancing of performance, schedule, cost and supportability is largely ignored. In its place is a concern for a required supportability at the minimum cost. One must then conclude that ILS and LCCM are not pseudonums. While a good LCCM program would doubtlessly have a good ILS program, the roles cannot be reversed. Now for some more detail on LSA.

LSA IN MORE DETAIL

The LSA process is a group of subtasks performed by government and contracting organizations. There are some 77 subtasks identified in MIL-STD 1388-1A. These are grouped into 15 tasks, which are grouped into five task sections. The first task section deals with management and control of the LSA Program. Tasks within this section include developing a strategy, a plan, and program/review procedures for the LSA program. The second task section is where LSA work actually begins. These task deal with comparison of the proposed new system/equipment with existing system/equipment, analysis of supportability, cost and readiness drivers. This comparison results in supportability objectives and supportability related design goals, thresholds, and constraints for the new system/equipment. A key element in this task section is the use study, which entails field visits to those most comparable locations. This task section provides the ammunition for successful trade-offs during the next task section.

The third task section deals with preparation and evaluation of logistics alternatives. Using information from the previous task section, and other inputs, the support requirements are tied down. Alternative support concepts are then identified and analyzed. A LCCM type trade-off is then performed to achieve the best balance of cost, performance, schedule, and supportability. The logistics requirements of this best alternative are then addressed in task section four.

Task section four takes the results of task section 3, and identifies the logistics support resource requirements. This entails identification of new or critical support requirements, and requirements for training, transportability, and provisioning. It also requires analysis of the expected impacts and interactions when the new item is fielded, and after production, e.g. "Will sources of supply parts remain available when production ceases?"

Task section five is basically a tracking and feedback procedure. Tests are performed to see if the quantitative supportability requirements are satisfied. Deficiencies. once known, should be corrected. This section provides the data needed for verification of earlier predictions. It closes the loop.

Each task and subtask within each task section is discussed in MIL-STD 1388-1A in clear terms. Most are logical. Anyone interested in more detail on the tasks should not hesitate to read through the standard. It is also important to note that tailoring of LSA to the program is encouraged. Appropriate tasks should be selected and even modified based upon the acquisition program characteristics. Andrews (1986) indicates it is very important that the LSA program (military standard) be tailored both to the complexity of the program and to the phase of the acquisition cycle that the program is entering.

RESULTS OF LSA

As in LCCM, LSA can have the desired impact only if it can be addressed early in the program while designs are still free. Butler (1985) indicates that in design, the early decisions have the greatest impact yet are the easiest to make. This is because later decisions are constrained to be consistent with those made previously. One standard curve indicates that the ultimate life cycle cost is rapidly locked in by the early design decisions. On average it is accepted that about 85% of the LCC is locked in by decisions made by Milestone II. A recent Swedish radar program found that over half of the design decisions were made in the first three months; 1500 out of 2700 total decisions. Butler claims this is considerably faster than our standard: it certainly supports the need for early consideration of supportability if we are to have any effect on the design.

The LSA and LSAR tasks are contract items and thus increase the contract cost. For example, ILS is generally considered to increase acquisition (factory door) cost by incorporating equipment modularity, accessibility, human factors, and increased reliability. (Carson 1969) The increase in early costs due to LSA must then be compared to expected reductions in later costs that can be attributed to LSA.

The cost effectiveness of LCCM programs was illustrated by early reprocurements. Consideration of life cycle costs resulted in procurement of replacement parts and supplies with much better cost characteristics, without sacrificing performance or schedule. This option for validation does not appear to be easily available for LSA since it is primarily used on new acquisition programs and on major modifications. One recent case study of a radio acquisition program compared the cost of LSA to the savings due to LSA. This study indicated that the cost was $2.1 Million, and the tangible benefits were about $69 Million. Of this $69 Million, most ($65 Million) was due to changing the power source to a standard, common battery. The study authors acknowledge that this savings might have occurred without LSA. Several other design changes made due to the LSA program on this radio were :

- 0 Changed an LRU to a module.
- 0 Added access panels, indicator sensors, larger openings.
- 0 Removed a roll pin (for easier maintenance).
- 0 Made a high failure rate keyboard a plug-in item.
- 0 Lengthened a grounding strap for easier mantenance.
- 0 Used more built-in-test capability.
- 0 Used more common integrated circuits.

(SINCGARS Study, 1985)

Several of the benefits attributed to the LSA analysis did not result in contributions to the "tangible benefits". When cost benefits could not be estimated through reduced material costs, they were listed as intangible. For example, maintenance manhour savings were typically listed as intangible. LSA savings are thus probably understated. No other studies were found that even purported to compare the costs of LSA to its benefits.

QUESTIONS/COMMENTS ABOUT LSA AND LSAR

There are a number of problems that have been identified with implementation of the DOD program for improved supportability. The proper definition of logistics goals is a problem. How can proper goals be defined in the program's directives so that these can be translated into achievable, verifiable goals for the contractors? Another problem is identified as goal conflict. How do you properly balance the competing goals of performance and supportability? A third problem is getting the right logistics sensitive people into the cycle, or as Hull and Lockhart (1982) indicated "the failure to employ appropriately skilled logisticians during the different phases of the acquisition cycle." All three of the above were rated as significant barriers to ILS by Hull and Lockhart.

Earlier, Carson (1969) indicated that the principle of deferred risk was behind some of the problems with planned logistics support. Solving todays problem with tomorrows resources is attractive to todays manager. The hope is that something will rescue the manager before the problem (which becomes tomorrows problem) reappears. Carson indicated this was why program managers tend to first cut human factors, then cut logistics support whenever problems occur and resources are needed now.

It is well known that acquisition managers become involved with their program. As Deputy Under Secretary of Defense (Acquisition Management) Long (1981) indicated, most in the acquisition process "have an underlying belief that systems will work as advertised." As such they tend to weaken the test and evaluation phases, even for the system hardware. What emphasis is then placed on supportability testing? Even though Carson (1969) indicated that mission readiness, availability, and safety are (should be?) totally overriding program objectives, the difficulty in relating supportability to these in measurable terms causes problems.

Another problem area is the data. Butler (1985) indicated that analysis requires data, yet data are only produced as a by-product of design. Butler concludes that design must therefore proceed analysis. Since ILS and LSA require that logisticians make inputs early during the design process, what is to done? As Carson (1969) indicated, the effectiveness of ILS (and LSA) depends upon documentation to record and distribute changes in ongoing programs. This history also provides a large portion of LSA's third task section dealing with preparation and evaluation of logistics alternatives. Only by documenting present experience can we hope to do better in the future. In addition, data required for the LSA is in some cases duplication of data needed elsewhere. Biedenbender (1985) indicated that when data is common to two data reports, the question of who enters the data becomes important. His example deals with R&M data required under MIL-STD-1629, but also required under LSAR. The details of who enters this data is often not specified in contracts.

The support for LSA is not unanimous. Hull and Lockhart quote one logistician as saying "LSA is often alleged to be redundant, unreliable, and very costly, particularly if the data requirements are extensive. For these reasons, many principals in acquisition perceive LSA as being an ineffective and inappropriate tool for some applications."

SUMMARY

According to Magruder (1957), acquisition entails obtaining the resource needed in the configuration required by whatever means is most efficient and economical. Since that time we have come to understand that the configuration must also be congruent with a logistics system that will allow it to be supportable. Since different combinations of configuration and logistics support system would result in different readiness, sustainability, cost and safety characteristics, thorough planning is desirable. Carson (1969) related that the final moment of truth lies in the levels of performance and value achieved after the system is in the hands of the user. Depending upon chance for good system characteristics is not the favored approach, thus the requirement for logistics planning.

The goals of LCCM, ILS, and LSA are consistent. In general, LSA is part of an ILS program. The primary difference between them is the reduction in scope from LCCM down to LSA. All strive for the best balance between performance, schedule, cost and supportability within their differing scopes.

AREAS FOR FURTHER RESEARCH

Norton and Cronin indicate that we are still learning how to put LSA/LSAR on contracts. One question surfaced by discussions with LSA personnel in AFLC/MMS and AFALC was "What LSA tasks should be applied to the various types of contracts?" Another was "Which Data Item Descriptions (DIDs) can be deleted if LSAR is on the contract?"

A large and more difficult question is "How can the effects of the LSA process be evaluated?" The SINCGARS study is one useful approach, that of the case study. But, is there any way samples can be gathered for statistical analysis? The answer to this is not trivial. If such samples cannot be gathered then the evaluation of the cost effectiveness of LSA will depend upon case studies and subjective evaluation.

This paper is the result of a literature search on LSA and ILS, and discussions with LSA focal points in HQ AFLC/MMA and AFSC's Aeronautical Systems Division. Remarkably little literature was found that specifically addressed LSA. The high volume of seminars and workshops that are continually offered on LSA would imply much more activity in this area. This work was primarily done for AFLC/MMA (Mr. Jim Cooley) and AFBRMC (Maj Rich Collins). Any errors or interpretation are solely my responsibility.

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

AD-A171 914

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: Unclassified

1b. RESTRICTIVE MARKINGS:

2a. SECURITY CLASSIFICATION AUTHORITY:

2b. DECLASSIFICATION/DOWNGRADING SCHEDULE:

3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S): AU/AFIT/LSQ-86-1

5. MONITORING ORGANIZATION REPORT NUMBER(S):

6a. NAME OF PERFORMING ORGANIZATION: Department of Quantitative Management

6b. OFFICE SYMBOL *(If applicable)***:** AFIT/LSQ

6c. ADDRESS *(City, State and ZIP Code)***:**
Air Force Institute of Technology
School of Systems and Logistics
Wright-Patterson AFB OH 45433-6583

7a. NAME OF MONITORING ORGANIZATION:

7b. ADDRESS *(City, State and ZIP Code)***:**

8a. NAME OF FUNDING/SPONSORING ORGANIZATION:

8b. OFFICE SYMBOL *(If applicable)***:**

8c. ADDRESS *(City, State and ZIP Code)***:**

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER:

10. SOURCE OF FUNDING NOS.

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.

11. TITLE *(Include Security Classification)***:** Logistics Support Analysis in Life Cycle Cost Management

12. PERSONAL AUTHOR(S): Mr. Roland D. Kankey

13a. TYPE OF REPORT: Technical

13b. TIME COVERED: FROM ______ TO ______

14. DATE OF REPORT *(Yr., Mo., Day)***:** 1986 August 18

15. PAGE COUNT: 18

16. SUPPLEMENTARY NOTATION:

17. COSATI CODES

FIELD	GROUP	SUB. GR.
15	05	
14	01	

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)***:** Logistics Support Analysis, Life Cycle Cost, Life Cycle Cost Management, Integrated Logistics Support

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

Life Cycle Cost and Life Cycle Cost Management opened another dimension of complexity for DoD mangers. Logistics Support Analysis is seen by some as a competing subject. This literature review considers life cycle cost, logistics support analysis, and integrated logistics support. Conclusions are that logistics support analysis is a proper subset of integrated logistics support, while integrated logistics support is a proper subset of life cycle cost management.

Further research is needed to verify the cost effectiveness of logistics support analysis. If data cannot be gathered for a proper statistical analysis, then more case studies such as the SINCGARS (1975) study need to be performed.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐

21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL: ROLAND D. KANKEY

22b. TELEPHONE NUMBER *(Include Area Code)***:** 513-255-8410

22c. OFFICE SYMBOL: AFIT/LSQ

DD FORM 1473, 83 APR — EDITION OF 1 JAN 73 IS OBSOLETE.

SECURITY CLASSIFICATION OF THIS PAGE

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10-86
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