LOGISTIC SUPPORT COST COMMITMENTS
FOR LIFE CYCLE COST REDUCTION

June 1977

Dwight E. Collins

LOGISTICS MANAGEMENT INSTITUTE
4701 Sangamore Road
Washington, D. C. 20016

PREFACE

The Office of the Secretary of Defense, the Military Departme. .₃ and defense contractors have been actively concerned for some time about rising life cycle costs (LCC) of Defense weapon systems.

Over the past several years, the Department of Defense (DoD) has placed new emphasis on examining and managing the projected operating and support (O&S) costs of planned weapons and finding ways to reduce those costs. O&S cost analyses are now a major part of the cost review conducted at each weapon procurement decision meeting by the Defense Systems Acquisition Review Council (DSARC) and the DSARC's principal advisor on new system costs—the Cost Analysis Improvement Group (CAIG).

In support of the DSARC/CAIG review of system O&S costs, LMI was assigned the task: "Life Cycle Cost Analysis in Support of the DSARC." The goal of the task was to develop O&S cost review procedures and estimating methodologies that the DSARC/CAIG would find useful in assessing the cost-effectiveness of new weapon systems, and to develop techniques for increasing cost reduction incentives.

This report is a product of this task. It contains the results of an analysis of the Logistic Support Cost (LSC) Commitment, a contracting technique used to transmit Government LSC reduction goals to the Contractor during the equipment development and production phase. In particular, the incentives and risks associated with the LSC Commitment are investigated.

The analysis should be of interest to program managers and cost analysts in the Military Departments, and to decision-makers in the defense industry concerned with structuring and using LSC Commitments.

ii

ACKNOWLEDGMENTS

EXECUTIVE SUMMARY

In its efforts of recent years to reverse the trend of increasing operating and support (O&S) costs of weapon systems and equipment, the Department of Defense (DoD) has begun to use several new contracting techniques to transmit Government cost reduction goals to the Contractor during equipment development and production. One of these techniques is the Logistic Support Cost (LSC) Commitment. The LSC Commitment has three primary elements: (1) a target logistic support cost (TLSC) defined in terms of a cost model framework, (2) a field verification test procedure, and (3) a contract remedy or price adjustment based on verification test results.

This report summarizes results of a recent study which investigates the incentives conveyed by the LSC Commitment and the risks accompanying its implementation. It focuses particularly on the impact of statistical risk on the interpretation of verification test results, and presents guidance for structuring future LSC Commitments.

The study has led to the following observations:

- The use of a simplified cost model framework as a basis for logistics targets and measurements provides a mechanism for focusing Contractor design efforts on equipment characteristics affecting failure rates and repair requirements commensurate with the relative impacts of these characteristics on LSCs. However, the framework must be developed with care to ensure that it summarizes these cost impacts accurately while simultaneously being simple enough to be interpreted without confusion in a contracting environment.

- Analytical techniques developed in this study can be used to assess trade-offs among alternative LSC Commitment model frameworks, risks, thresholds, and test lengths. Through this analysis, those LSC Commitment configurations that most effectively convey Government LSC reduction goals to the Contractor can be found.

- The simultaneous verification of several logistics parameters in the operational environment called for by the LSC Commitment tends to result in either high statistical risks to Contractor and Government or unacceptably long field verification test periods. The technique of applying the LSC Commitment with respect to an aggregation of equipment items results in reduced risks, and hence, may provide a workable solution to this problem. But the technique has the potential drawback of masking poor logistics performance of a small number of equipment items in the aggregation. While this attribute is not a matter of primary concern from the standpoint of aggregate LSC expenditures, it may contribute to reduced visibility of logistics performance impacts on weapon system readiness.

- The LSC Commitment is an innovative contracting technique. It embodies the appealing concept of a macro target to summarize aggregate costs and transmit multiple incentives to the Contractor. However, because it has been used in only a small number of contracts to date, the LSC Commitment's effectiveness as a contracting and management tool requires continued evaluation. Future applications should be on a selective and controlled basis.

TABLE OF CONTENTS

LIST OF FIGURES

I. INTRODUCTION

During the past few years, the management concept of "Design to Cost" (DTC) has been implemented with considerable success by the DoD. A variety of system and equipment acquisition programs have incorporated an average unit flyaway (rollaway, or sailaway) cost target in the development/production contract early in the development phase, in order to control program costs throughout the development and production processes.[1] As experience in implementation of the DTC concept has accumulated, however, there has developed a widespread awareness of the need for broadening it to encompass not only development and production costs but also operating and support (O&S) costs. Indeed, DoD Directive 5000.28 [5, p. 3] states that

> as the ability to translate O&S cost elements into 'design to' requirements improves, Design to Cost goals may be extended into this area.

It also states that, at a minimum,

> the major operating and support cost factors shall have goals established in the form of measurable numbers (e.g., numbers of O&S personnel, reliability and maintainability factors, etc.) which can be monitored during test and evaluation as well as in operation.

The Joint Logistics Commanders' Design to Cost Guide [4, pp. 23-24] also stresses the need for contractual O&S cost goals, stating that these goals must be tailored to address those portions of O&S costs which are "design dependent, predictable, and verifiable." In

---

[1]"Design to Cost" is defined by DoD Directive 5000.28 [5] as "a management concept wherein rigorous cost goals are established during development and the control of systems costs (acquisition, operating and support) to these goals is achieved by practical tradeoffs between operational capability, performance, cost, and schedule. Cost, as a key design parameter, is addressed on a continuing basis and as an inherent part of the development and production process." Flyaway cost is defined in DoD Manual 7110.M [8] to include the cost of procuring the basic unit (airframe, hull, chassis, etc.), a percentage of basic unit cost for changes allowance, propulsion equipment, electronics, armament, other installed Government-furnished equipment, and nonrecurring production costs.

tactical unit which must be able to deploy quickly and remain self-sufficient in its repair function. Second, the LSCC covers a broader range of equipment logistics performance attributes than the RIW, particularly at the field level. For example, trade-offs involving unit price of spares and preparation and access time in the field are explicitly addressed, unlike the RIW.

Two recent procurements in which the LSCC has been incorporated are the AN/ARN-101 tactical LORAN, managed by the Air Force Electronics Systems Division (ESD) at Hanscom AFB, Mass., and the F-16 aircraft, managed by the Air Force Aeronautical Systems Division (ASD) at Wright-Patterson AFB, Ohio. In the case of the F-16, the LSCC is in effect at two levels. First, there exists a "system-level" TLSC, a target LSC with respect to the aggregate of 280 of the aircraft's line replaceable units (LRUs). The LSCC includes a multi-million dollar award fee provision with respect to this target but no negative incentive. Second, there exists a TLSC specifically with respect to three of the aircraft's high cost LRUs: the fire control radar, the electro-optical (E-O) display, and the E-O display electronics. The LSCC includes provisions for both positive and negative contract adjustments with respect to this latter TLSC.

This report summarizes results of recent research into the incentives transmitted to the Contractor by the LSCC and the risks associated with its implementation. Particular attention is paid to the impact of statistical risk on the interpretation of test results relative to the contractual target. The report presents several critical insights into the statistical risk properties of the LSCC and discusses how these insights can be utilized in structuring future LSCCs. It demonstrates the importance of a clear and adequate assessment of these risks as a precondition to the effective use of contractual O&S cost targets by the DoD in its efforts to reduce system and equipment life cycle costs.[4]

---

[4]The term "risk" is used here to describe situations in which the decision-maker does not know the relevant consequences of decision alternatives under consideration with complete certainty. The precise definitions of risk and uncertainty are different [7, p. 13]. However, because of the summary nature of this report, no attempt is made herein to distinguish between risk and uncertainty.

addition, it emphasizes the need for formulating O&S cost goals in terms of dollars, stating that

> in order to balance all the elements of production and operating and support costs with performance and schedule, ... it is necessary to convert the measures of reliability and maintainability, such as MTBF and MTTR, into expressions of cost.[2]

The DoD has begun to experiment with several techniques designed to transmit DoD O&S cost goals to the Contractor. One such mechanism used by the Air Force in several recent procurements is the Logistic Support Cost Commitment (LSCC), sometimes referred to as a Support Cost Guarantee. The LSCC has three key elements:

1. A target logistic support cost (TLSC), defined in terms of a logistic support cost (LSC) model framework

2. A field verification test procedure, including computation of a "measured" logistic support cost (MLSC)

3. A contract remedy or price adjustment, which is a function of verification test results (particularly the MLSC).

The LSCC has certain attributes not shared by the Reliability Improvement Warranty (RIW), another mechanism for reducing support costs now being used selectively by the DoD.[3] First, it is more appropriate in cases where the retention of an organic (internal) maintenance capability at base level is dictated by mission or policy requirements, e.g., a

---

[2] The symbols MTBF and MTTR are the acronyms for "Mean Time Between Failure" and "Mean Time to Repair," respectively.

[3] The RIW is a contractual agreement under which the Contractor assumes responsibility for all repair of an item over a given interval of time (e.g., three to five years) at a prenegotiated fixed price. One of its key objectives is to provide a contractual framework under which increased equipment reliability leads to increased Contractor profits. It typically encourages the Contractor to make engineering changes to failed items during his repair process at no cost to the Government in order to reduce their subsequent failure rate, and hence return rate to his facility. In those cases when the RIW is negotiated in conjunction with the item development/production contract, it provides the Contractor with the additional incentive to incorporate a higher level of reliability in the item at the outset.

Nine of the F-16 aircraft's high cost avionics subsystems (e.g., inertial navigation unit (INS), flight control computer, heads up display (HUD), etc.) are covered by a four-year RIW.

Chapter II describes the incentives that the LSCC is structured to transmit. Chapter III surveys a variety of management issues associated with implementation of the LSCC concept and Chapter IV deals with statistical risk.

II. THE LSC COMMITMENT STRATEGY: TRANSMITTING MULTIPLE INCENTIVES WITH AN LSC TARGET

THE ROLE OF THE COST MODEL FRAMEWORK

The LSCC uses a simplified cost model framework to represent Government LSCs as a function of Contractor-controllable equipment logistics parameters in the manner recommended by the Joint Logistics Commanders' Design to Cost Guide [4, pp. 23, 24]. Figure 1 reflects an LSC framework typical of those used in recent LSCC applications. (A list of model parameter definitions appears in Appendix A.) Such a cost model framework (CMF) is usually developed by program office or acquisition management staff personnel and provided to competing contractors as part of the LSCC provisions, ultimately becoming part of the negotiated contract. The CMF establishes a basis for formal communications between Contractor and Government regarding LSCs.

The underlined parameters in Figure 1 (e.g., MTBF and NRTS) reflect hardware logistics characteristics over which the Contractor has a degree of control through his design engineering process. These are typically targeted by the Contractor in the equipment proposal. Subsequently, they are estimated or "measured" during a field verification test, which covers a period of from 3,000 to 6,000 hours of operation of the equipment in its field environment. Virtually all remaining model parameters (e.g., M = number of bases to which the equipment will be deployed) describe the environment in which the equipment will operate and be maintained, and are supplied by the Government with the model framework.[5]

The negotiated contract includes a target LSC (TLSC) which reflects the LSC impact of the various Contractor-targeted equipment logistics parameters. This target

---

[5]In most recent LSCC applications, one other critical equipment parameter, unit cost (UC) of spares, has also been targeted by the Contractor to be subsequently "measured" in the field. However, the "measured" value in these cases is simply the negotiated unit cost of spare items as of the end of the verification test. Hence, it is clearly not estimated in the statistical sense in which the other targeted parameters are estimated.

FIGURE 1. A TYPICAL LSC MODEL FRAMEWORK[1]

C_1 = cost of initial spare items

= (Cost of base repair pipeline spares) + (Cost of depot repair pipeline spares)

= $(M) (\underline{STK}) (UC) + \left[(PFFII) (UF) (QPA) (1 - RIP) (\underline{NRTS}/(\underline{MTBF})\right] (DRCT) (UC)$

where STK is the minimum value of i such that

$XBO(i, \lambda t) = \underset{x > i}{\Sigma} (x - i) P (x \mid \lambda t) \leq EBO$, $P (x \mid \lambda t)$ is Poisson, and

$$\lambda t = \left(\frac{(PFFH) (UF) (QPA) (1 - RIP)}{(M) (\underline{MTBF})} \right) \left((\underline{RTS}) (\underline{BRCT}) + (\underline{NRTS}) \left[(OSTCON) (1 - OS) + (OSTOS) (\underline{OS}) \right] \right)$$

C_2 = cost of on-equipment maintenance

= (total mean number of failures) x (average on-equipment repair cost per failure)

= $\left[(TFFH) (UF) (QPA)/\underline{MTBF} \right]$ x $\left[\underline{PAMH} + (\underline{RIP}) (\underline{IMH}) + (1 - RIP) (\underline{RMH}) \right]$ x BLR

C_3 = cost of off-equipment maintenance

= (total mean number of off-equipment repairs) x (average cost per off-equipment repair)

= $\left[(TFFH) (UF) (QPA) (1 - \underline{RIP})/\underline{MTBF} \right]$ x $\left[(\underline{RTS}) (\underline{BMH}) (BLR + BMR) + (\underline{NRTS}) (\underline{DMH}) (DLR + DMR) \right]$

---

[1] Where possible, definitions (see Appendix A) and symbology appearing in this typical LSC model framework are identical to those used in the Air Force Logistic Command's LSC Model. This model is described in [3]. A further assessment of the model as a tool for comparison of competing systems, trade-off analysis, program cost and performance tracking, and trend evaluation can be found in [1].

exists in addition to other contractual goals and targets such as a DTC goal on average unit flyaway cost. At completion of the field verification test, "measured" values of these parameters are inserted into the CMF in place of their corresponding Contractor-targeted values and the resulting cost value is called the measured LSC (MLSC). A positive or negative contract adjustment is made as a function of whether the Contractor meets or underruns his LSC target (MLSC $\leq$ TLSC) or overruns it (MLSC > TLSC).

BENEFITS OF A COST TARGET

The type of CMF used in the LSCC provides the Contractor with considerably more design flexibility in his efforts to achieve Government LSC reduction goals than he would have if individual contractor targets were incorporated with respect to reliability (R), maintainability (M), level of repair, etc. For example, suppose the Contractor discovers after he is well into his design effort that he cannot achieve the MTBF target to which he committed himself in the contract without initiating a large reliability improvement program at considerable cost to himself (and to the Government in the case of a cost-type contract). If the CMF suggests that this MTBF reduction can be offset by decreasing the projected percentage of failures requiring depot repair, i.e., reducing the NRTS rate, and if this alternative can be carried out through a less costly design change than a reliability improvement program, then the Contractor is encouraged to take it under the terms of the LSCC.[6]

The CMF reflects the LSC impact of interactions among logistics parameters that would not be captured by individual R&M targets. For example, equation C_1 in Figure 1 reflects the dramatic impact of a low MTBF-high NRTS combination on LSC much more realistically than separate targets on reliability and repair level would. The CMF also provides a perceptual advantage by reflecting logistic support impacts of equipment

---

[6]It is assumed in this illustration that the unforeseen decrement in reliability will not violate other terms of the contract, e.g., targets with respect to mission reliability weapon system availability, etc.

characteristics in terms of dollars. This facilitates a more effective analysis of trade-offs between acquisition cost and LSC impacts of equipment design expenditures. Finally, the CMF provides the Contractor with a tool for analyzing the relative sensitivity of the LSC of his equipment to the various equipment logistics parameters over which he has control. As he gains experience in designing with the CMF explicitly in mind, he should become expert at trading off within this framework, as well as between LSC and costs of production, so as to converge to a minimum LCC design.

COST MODEL ACCURACY AND COMPREHENSIVENESS

It should be noted that the type of CMF reflected in Figure 1 does not necessarily project the actual increment of LSC that will result from introducing the proposed equipment item into the Government inventory. Rather, it is simply a surrogate or representative "figure-of-merit" for real costs of logistic support during equipment operation. It summarizes the cost impact of projected demands for support resources by the item, but it does not address indirect and policy-driven LSCs or interdependencies among different support resources.

For example, suppose an item of electronics is purchased by a military service and the procurement includes an LSCC, in particular, the CMF in Figure 1. The Contractor has targeted the fraction of base shop repairs to be .90 and the primary elements of LSC for this item are projected to be spares, on-equipment maintenance, and off-equipment maintenance. An equation for support equipment (SE) is not included in the CMF because (1) all SE required by the new item is common to that required by several other items already in the inventory, and (2) there appears to be enough slack in the demand for this existing SE to sustain the level of added demands projected for the new item.

When the new item is deployed, a variety of factors in addition to those summarized by the CMF will impact the ultimate increment of LSC incurred by the Government. Perhaps the increase in demands on the existing SE causes more queuing of failed items

8

and a longer repair cycle. This may call for the purchase of additional spares of certain items or a change in the policy of manning the base shops, at an increase in cost. Or perhaps the heavier SE usage rate causes a dramatic increase in SE failures and because of a paucity of SE spare parts, a much larger fraction of failed prime hardware must be sent to the depot for repair at an increase in cost.

The type of CMF shown in Figure 1 does not reflect all these interactions because it is not meant to be a substitute for comprehensive support planning. Proper execution of the support planning function, which should address the interdependencies described above, requires a sustained cooperative effort by both Contractor and Government throughout the equipment development and production phase. The use of the LSCC and in particular, the summary type of CMF shown in Figure 1 is intended simply to formalize the Contractor's role in the overall support planning function and to provide him with a better defined financial interest in finding the least cost support postures.

Increasing the accuracy and comprehensiveness of the CMF representation in the context of the LSCC involves an important trade-off. Presumably, it would be desirable to reflect some of the more complex types of support resource demand behavior currently experienced by the DoD in the CMF, since these demands consume a significant portion of DoD budget dollars, and it would be desirable for the Contractor to have an explicit financial interest in eliminating some of their causes. The CMF in Figure 1 does this to some extent. For example, the detailed base-level spares computation in equation C_1 reflects the step functional dependence of the demand for spare items at a given base on the failure rate (or MTBF) in a manner illustrated by Figure 2. It indicates, for instance, that increasing the MTBF from 275 hours to 450 hours would not reduce the requirement for base-level spares and result in reduced LSCs even though it would have a positive impact on aircraft availability. It would be useful to consider extending the CMF in the spirit of this example to reflect ultimate LSCs incurred more realistically in related

9

FIGURE 2. THE DEMAND FOR BASE SPARES
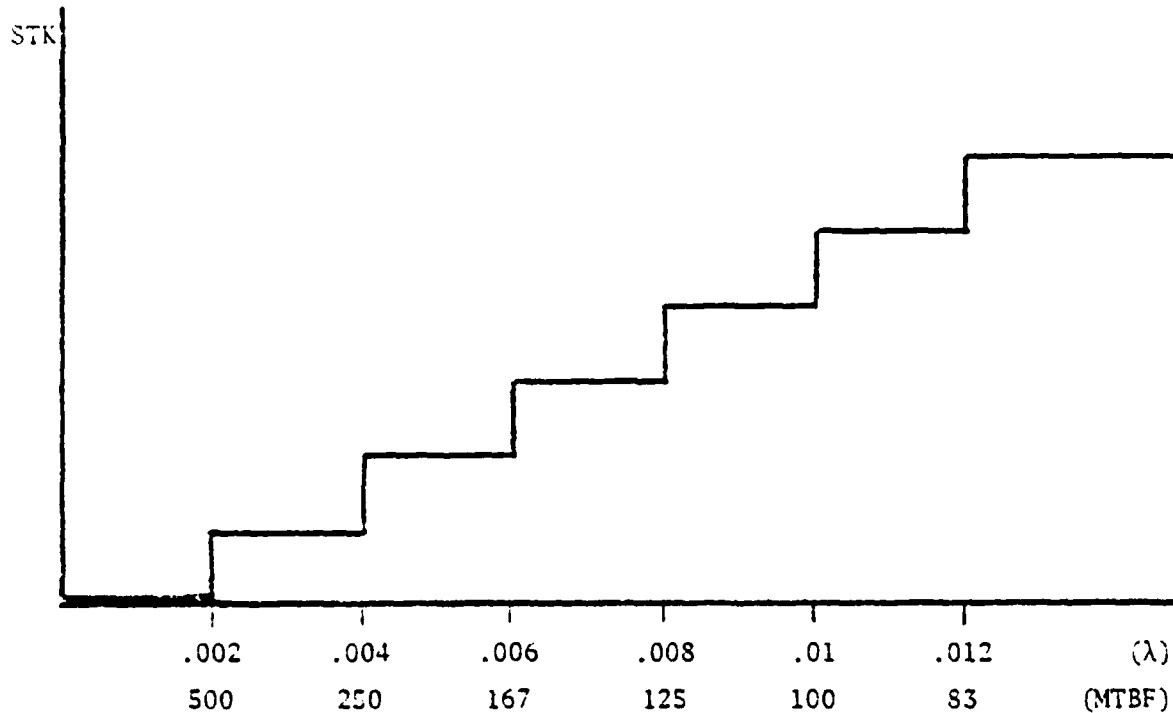
where: λ = the failure rate of the equipment item

STK = the number of spares of the item required at a given base
(including safety stock) to guarantee a given prestated
level of equipment availability

areas, such as costs of maintenance personnel and support equipment. But, as the accuracy and comprehensiveness of the CMF is enhanced, its mathematical complexity increases. Whereas this would not cause particular difficulty in an analysis environment, it is definitely not a desirable attribute in the context of the LSCC. As the complexity of the CMF increases, contractual responsibilities under the LSCC become harder to delineate, risks to Contractor and Government become more difficult to assess, and the LSCC tends to stimulate more questions and fewer LSC reduction incentives. Hence, great care must be taken in any efforts to enhance CMF accuracy to ensure that questions of legal responsibility and risk are adequately addressed.

10

III. IMPLEMENTATION CONSIDERATIONS

The LSCC is a complex legal document. Hence, there are numerous management decisions and issues that require considerable attention in order to implement the LSCC for one or more given equipment items. The paragraphs below highlight some of these issues.

DEFINING THE VERIFICATION ENVIRONMENT

The LSCC typically includes considerable detail regarding such areas as failure definition, parameter estimate definition, and specific responsibilities of both Contractor and Government during the period of verification. For example, it must carefully define a failure in terms of various combinations of How Malfunction Codes and Action Taken Codes. It must clarify how to treat failures resulting from faulty test equipment and failures due to fire, crash, etc. The method of estimating or "measuring" each equipment parameter subject to verification must be clearly spelled out. In most cases, these "measurements" are simply sample means of sets of observations.[7]

The LSCC must address questions regarding the method of selecting units to be tested, the training and organization of people performing maintenance on the equipment during the test, the nature of Contractor representation during the period of testing,[8] and

---

[7]In the case of the high cost LRU portion of the F-16 LSCC, these sets of observations will consist of certain Air Force 66-1 records verified by a base-level audit. There is no verification of the depot-level parameter, DMH (depot repair hours per failure) under this LSCC provision for two reasons: (1) it is difficult and costly to set up and manage special verification procedures at the depot, and (2) since the items involved have low NRTS rates (e.g., .05-.10), few failed items over a verification test period of just a few thousand hours would be sent to the depot for repair and hence, there would be few observations upon which to build an estimate of DMH.

[8]The Contractor typically has the right to inspection of all Government-identified failures and representation during all base-level equipment maintenance operations except for removal and replacement.

the length of the test period. It must also specify the conditions under which an adjustment in the TLSC prior to the verification test is allowed, e.g., approval of certain kinds of engineering change proposals (ECPs), changes in anticipated force structure, or inflation factor adjustments.

DEVELOPING CONTRACT ADJUSTMENT PROCEDURES

The comparison of the MLSC to the TLSC is typically used as a basis for various kinds of contract remedies or price adjustments. If the MLSC is less than the TLSC, suggesting that the contractor has more than achieved his LSC target, either of two types of positive adjustment can be used: (1) an award fee, the amount of which (up to a maximum specified in the LSCC) is determined by the Government as a function of the difference between the MLSC and the TLSC and other logistic support cost performance criteria; or (2) an upward price adjustment, the simplest form of which is payment of a higher purchase price per unit. In the latter case, the amount of price adjustment is usually some function of the difference between the MLSC and TLSC and must be specified by a schedule appearing in the LSCC.[9]

If the MLSC exceeds the TLSC by some small amount, say 5-10%, the Contractor is usually given the benefit of the doubt and no contractual remedies with respect to LSC are required. However, a value of MLSC larger than some threshold value, e.g., 1.25 x TLSC, is typically regarded as sufficient evidence that the LSC performance of the Contractor's equipment is inadequate. For MLSC values in this region, one or more of the following three forms of Contractor remedy is usually called for by the LSCC:

1. Exercise of a correction of deficiencies (COD) clause, the terms of which specify that the Contractor must improve the LSC performance of the

---

[9]One recent Air Force procurement incorporating this price adjustment provision is the ARC-164 UHF radio (managed by the Aeronautical Systems Division at Wright-Patterson AFB, Ohio), whereas the F-16 aircraft LSCC makes extensive use of the award fee provision.

12

equipment to the satisfaction of the Government. Costs of these improvements may be shared by the Contractor and the Government depending on the type of contract specifying this agreement.[10]

2. Reduction of the purchase price in the form of reduced fee or a reduced price per item. In either case, the price adjustment may be a function of the difference between the MLSC and TLSC, the form of which is specified in the LSCC.

3. A requirement for the Contractor to provide, at no additional cost to the Government, additional spare equipment items to offset the indicated LSC overrun. Here, a function relating the spares requirement to the difference between TLSC and MLSC is typically included in the LSCC.[11]

MANAGEMENT OF COST RISK

The LSCC exposes both Contractor and Government to cost risk. It is most *important when structuring the terms and conditions of the LSCC that these risks be* confined to levels low enough to be acceptable. Figure 3 reflects the significance of cost risk relative to the Contractor's entire spectrum of risks. The Contractor faces two major kinds of risk: (1) financial risk, which can be viewed as the relative variability of earnings available to the common stockholder as a function of financing decisions and, in particular, the probability of insolvency $\left[9, \text{pp. } 145\text{–}147\right]$, and (2) business risk, which can

---

[10]This COD clause is a departure from COD clauses historically used with respect to operational performance. For example, the interpretation of the term "deficiency" is broader than and considerably different from the traditional interpretation. A deficiency with respect to LSC performance is defined to occur when the MLSC exceeds the TLSC to an unacceptable extent. This deficiency need not be defined relative to one aspect of LSC performance such as mean time between failures (MTBF) or mean time to repair (MTTR). Rather, a deficiency is defined to occur when poor performance relative to one or more of these logistics performance criteria combine to cause the unacceptably high MLSC. In addition, the period for notification to the Contractor concerning a deficiency is longer than traditional COD notification periods and the Contractor is permitted much greater flexibility in his corrective action.

[11]A further discussion of the use of positive and negative incentives in the LSCC can be found in $\left[6\right]$.

FIGURE 3. HIERARCHY OF CONTRACTOR RISKS

```
                    ┌─────────────┐
                    │    TOTAL    │
                    │  CONTRACTOR │
                    │    RISK     │
                    └──────┬──────┘
              ┌────────────┴────────────┐
      ┌───────┴───────┐         ┌───────┴───────┐
      │ BUSINESS RISK │         │ FINANCIAL RISK│
      └───────┬───────┘         └───────────────┘
       ┌──────┴──────┐
┌──────┴──────┐ ┌────┴────┐
│OTHER ELEMENTS│ │         │
│ OF BUSINESS  │ │ COST    │
│ RISK, E.G.,  │ │ RISK    │
│ PRICING,     │ │         │
│ MARKETING.ETC│ │         │
└─────────────┘ └────┬────┘
          ┌──────────┼──────────────┐
   ┌──────┴────┐ ┌───┴──────┐ ┌─────┴──────────┐
   │STATISTICAL│ │ TECHNICAL│ │OTHER ELEMENTS OF│
   │   RISK    │ │   RISK   │ │COST RISK, E.G., │
   └───────────┘ └──────────┘ │LABOR CONTRACTS, │
                              │RAW MATERIAL      │
                              │PRICES. ETC       │
                              └─────────────────┘
```
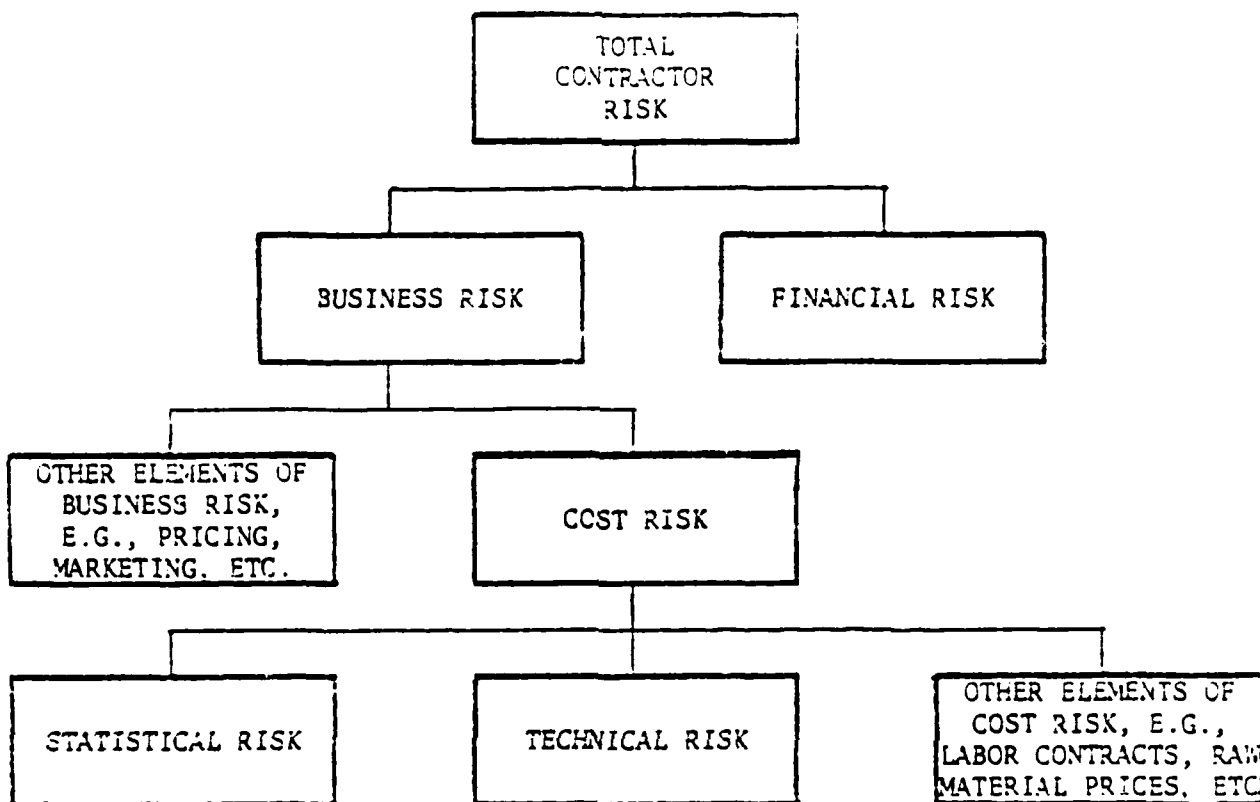
be viewed as the relative variability of the firm's net operating income $[9, p. 18]$.[12] Cost risk or potential variability of costs is a dominant element of business risk. Two primary elements of cost risk are particularly germane to the implementation of LSCCs: technical risk and statistical risk.

The detailed nature of the CMF typically incorporated in the LSCC tends to cloud the relationship between technical risk and statistical risk. In order to understand these

[12]Both business risk and financial risk are reflected in the "coefficient of variation" (CV) for the firm. This is defined as the ratio of the standard deviation to the expected value of the probability distribution of expected earnings available to common stockholders. Earnings in this case are defined as the firm's net operating income (NOI) from operations less fixed charges due to interest on debt, lease commitments, and preferred stock dividends. Business risk is defined to increase as the variability of the firm's NOI increases relative to its expected value, hence increasing the CV. Financial risk is defined to increase as the dollar amount of fixed charges due to financial leverage increases, hence decreasing the expected value of earnings and increasing the CV $[9, pp. 145-147]$.

risks, it is helpful to again consider the measured LSC (MLSC) derived from the verification test under the terms of the LSCC. Recall that the MLSC is a function of Government-supplied constants and estimates of Contractor-targeted parameters such as MTBF and NRTS. The estimates of these parameters have variability; that is, if the test during which a given estimate is being compiled could be repeated again and again under identical conditions, the value of the estimate resulting from each replication of the test would very likely differ from previous values. Since the estimates of all contractor-targeted parameters have variability and since the MLSC is a function of these estimates, it too is an estimate having variability.

Let us refer to the underlying true population LSC value defined in terms of the CMF and estimated by the MLSC as the MMLSC.[13] Since the MLSC may differ significantly from the MMLSC, it is possible that incorrect conclusions regarding equipment LSC performance can be drawn, leading to incorrect decisions regarding LSCC awards or remedies. For example, if an observation of MLSC exceeds the MMLSC, a COD clause may be invoked and Contractor remedies called for, when indeed the value of the unknown MMLSC may be less than the TLSC, indicating that the Contractor has in fact met his target. Conversely, if the MLSC is low relative to the MMLSC, it may be concluded that the Contractor should receive an award fee, when actually, the (unknown) MMLSC is high enough relative to the TLSC to indicate the inadequacy of the Contractor's equipment from an LSC performance point of view.

Statistical risk in the context of the LSCC is the risk of making incorrect award/remedy decisions because of differences between the MLSC and MMLSC of the type described above. In other words, it is the risk to both Contractor and Government of making incorrect award/remedy decisions because of variability of the MLSC. Technical

---

[13]It would be desirable to be able to determine the value of the MMLSC exactly, to compare this value to the TLSC and finally, to make decisions regarding contractual awards or remedies as a function of this comparison. But the MMLSC is impossible to determine with certainty. At best, it can only be estimated. Hence, its estimate, the MLSC, is used in its place in the comparison above and in the award/remedy decision process.

risk, on the other hand, is risk to both the Contractor and the Government due to variability in the possible values that the underlying MMLSC might take on relative to the TLSC. This risk is more a function of the Contractor's technical ability to deliver an item of equipment whose LSC characteristics are close to a preassigned target. This technical ability is, in turn, a function of the state of the art of the proposed equipment, the efficiency of the Contractor's manufacturing processes, the realism of the proposed development schedule, etc.

Technical risk and statistical risk should be addressed separately in structuring an LSCC. Both risks can have a significant impact on the effectiveness of the LSCC as a tool for transmitting incentives to the Contractor. If, for a given proposed item of equipment, technical risks are large and hence variability of ultimate LSC (as characterized by MMLSC) is large, then the use of an LSCC is unwise. Under these circumstances, the Contractor's MMLSC could turn out so high or so low relative to the TLSC that the enforceability of the LSCC could reasonably be questioned. In addition, the effectiveness of the LSCC as a means of transmitting an incentive to the Contractor to design a reduced LSC item of equipment would also be questionable.

The impact of statistical risk on the effectiveness of the LSCC is virtually as significant as the impact of technical risk. Even if technical risk is within reasonable bounds, the LSCC will provide little LSC reducing incentive to the Contractor if there is evidence of high variability in the MLSC measurement. Furthermore this variability could lead to (1) the needless expenditure of millions of dollars of both Contractor and Government resources if the Contractor's equipment is rejected when it is really adequate, or (2) the acceptance of the Contractor's equipment and subsequently, years of poor logistic performance and inflated LSC expenditures, when this inadequacy should have been identified by the verification test and subsequently rectified.

Given that technical risks are not prohibitively high, statistical risks can be controlled through appropriate structuring of the LSCC. Methods for maintaining statistical risks to Contractor and Government at acceptably low levels are described in Chapter IV.

KEEPING THE COMMITMENT LEGALLY MANAGEABLE

Due to the inherent complexity of the LSCC, particular attention should be focused on the legal implications of its terms and conditions. Of foremost importance is the issue of Contractor responsibility and liability versus Contractor control. The Contractor's responsibility for equipment LSC performance must be carefully balanced under the terms of the LSCC by sufficient authority to control those factors which cause LSCs to be incurred. The presumption underlying use of the LSCC is that these factors can be delimited to equipment parameters over which the Contractor clearly has design control by carefully structuring the LSCC. More specifically, it is assumed that the Contractor can reasonably be held responsible for LSC performance in operational, supply, and maintenance environments over which he clearly does not have total control by guaranteeing to him in the LSCC that those elements over which he does not have direct control such as the equipment operating environment and skill levels of maintenance personnel will be adequately maintained by the equipment user at specific prenegotiated levels. Clearly, the use of an LSCC with respect to the procurement of a new equipment item is not appropriate unless the use environment is stable enough to permit this condition to be met.

IV. STATISTICAL RISK PROPERTIES

CHARACTERIZING THE RISKS AND CONTROL PARAMETERS

The statistical risks underlying the LSCC can be completely described in terms of the following four quantities:

1. Statistical risk to the Contractor

2. Statistical risk to the Government

3. Length of the verification test period in total weapon system operating hours (= T)

4. An MLSC threshold above which a contract remedy is required.

The MLSC threshold is some given dollar amount larger than the TLSC. Let this quantity be called the remedy threshold, denoted by RT. It is convenient to be able to express the remedy threshold in terms of some factor (> 1) times the TLSC. Let the expression TF, reflect this threshold factor. By this convention,

$$RT = TF \times TLSC. \qquad \text{IV.1}$$

The development of the TLSC by the Contractor in his equipment proposal can be interpreted as his assertion that the underlying true population LSC value, MMLSC, to be estimated by the MLSC will be less than or equal to the TLSC, i.e.,

$$MMLSC \leq TLSC. \qquad \text{IV.2}$$

The LSCC also addresses the possibility that the Contractor's assertion may be false, i.e., that

$$MMLSC > TLSC. \qquad \text{IV.3}$$

The basic decision rule incorporated in the LSCC is (1) to seek no contract remedies if the MLSC does not exceed the remedy threshold, i.e., if

$$MLSC \leq TF \times TLSC, \qquad \text{IV.4}$$

and (2) to seek the remedy or negative adjustment if the threshold is exceeded, i.e., if

$$\text{MLSC} > \text{TF} \times \text{TLSC}. \qquad \text{IV.5}$$

The interval from the TLSC to RT = TF x TLSC represents a margin of safety in the Contractor's favor.

The statistical risk to the Contractor under the LSCC is simply the probability that the Government will reject his equipment when, indeed, he has met or underrun his target. Let us call this probability α. In terms of the conceptual framework presented above,[14] α is simply the probability of getting an MLSC value that suggests rejection of the Contractor's equipment when in reality, the underlying LSC value, MMLSC, which the MLSC is estimating, is less than or equal to his target, i.e.,

$$\alpha = \Pr(\text{MLSC} > \text{TF} \times \text{TLSC} \mid \text{MMLSC} \leq \text{TLSC}). \qquad \text{IV.6}$$

In order to develop an analogous expression for Government risk, we first define TLSC' to be the Government's "rejection target," that is, a specified value of MMLSC, greater than the remedy threshold, RT = TF x TLSC, at which the Government wants to ensure a high probability of rejection.[15] The statistical risk to the Government under the LSCC is defined to be the probability, henceforth called β, of getting an MLSC value that suggests acceptance of the Contractor's equipment when indeed, he has actually overrun his target to the extent that MMLSC = TLSC', i.e.,

$$\beta = \Pr(\text{MLSC} < \text{TF} \times \text{TLSC} \mid \text{MMLSC} = \text{TLSC'}). \qquad \text{IV.7}$$

We henceforth refer to α, β, T, and TF as the "control parameters" of the LSCC.

---

[14]A rigorous analytical description of this conceptual framework is presented in [2].

[15]The Government rejection target, TLSC', can be viewed as the "maximum acceptable" value of MMLSC. It is analogous to θ_1, the "minimum acceptable" MTBF used in the fixed and variable length reliability test plans defined by MIL-STD-781B. Similarly, the contractor target, TLSC, is analogous to the "specified" MTBF and hence, the ratio, TLSC'/TLSC, is largely analogous to the discrimination ratio, θ_0/θ_1, in MIL-STD-781B.

19

THE RISK ASSESSMENT MODEL: AN INTRODUCTION

As part of the study described in this report, a risk assessment model was developed which explicitly incorporates the mathematical relationships among the four control parameters defined above. The relationships indicate that a change in the value of one parameter cannot be achieved without a change in the value of at least one of the other three. For example, a change in test length (T), holding the threshold factor (TF) constant, results in changes in both Contractor risk (α) and Government risk (β). Alternatively, a decrease in Contractor risk, holding the threshold factor constant, can be achieved only at the expense of an increase in test length. Or if test length must be held constant but the threshold factor is allowed to vary, a decrease in Contractor risk can be achieved by increasing the threshold factor. However, this also results in an increase in Government risk.

Because of the complexity of the CMF used in the LSCC, the relationships among the control parameters are difficult to formulate precisely. This complexity can be overcome through efficient computer programming of the model, however. Such a set of programs can be used as a vehicle for explicit consideration of trade-offs among the four parameters. The example below illustrates the kinds of insights and information that it can provide.

EXAMPLE

Suppose that an LSCC is to be incorporated in the procurement of an item of avionics having an average unit production cost of $40,000-$60,000 and an MTBF ranging from 400 to 600 hours. Suppose that the Figure 1 CMF is used for the development of each bidder's TLSC and subsequent measurement of the MLSC in the case of the winning Contractor, henceforth called Contractor A. In particular, suppose that the Government-furnished program parameters and verification test parameters are as shown in Figure 4 and the equipment logistics parameter targets for Contractor A, along with Government rejection targets are as shown in Figure 5.

The flying hour values in Figure 4 represent official program office flying schedule projections, while the repair cycle times and labor/material rates have their origins in Air Force base and depot maintenance and supply accounting systems. The test length of 3,000 hours represents a figure negotiated between the program office and the item using command. The threshold ratio of 1.25 was developed through negotiation between Contractor A and the Government.

FIGURE 4. VALUES OF CMF PARAMETERS UNRELATED TO EQUIPMENT CHARACTERISTICS

PROGRAM PARAMETERS

PFFH	=	15,000 hrs./mo.	BLR	=	$11.70/hr.
TFFH	=	1,500,000 hrs.	BMR	=	$ 2.28/hr.
BRCT	=	.13 mo.	DLR	=	$12.44/hr.
DRCT	=	1.84 mo.	DMR	=	$ 6.72/hr.

TEST PARAMETERS

T	=	3,000 hrs.
TF	=	1.25

Note: Refer to Appendix A for parameter definitions.

FIGURE 5. VALUES OF CMF EQUIPMENT-RELATED PARAMETERS

CONTRACTOR A TARGETS (TLSC = $1,250,000)

UC   = $50,000
MTBF = 500 hrs.
UF   = 1.0, QPA = 1.0

Repair Level and Man-Hour Parameters

	RIP	RTS	NRTS	PAMH	IMH	RMH	BMH	DMH
U. Bound	0.0	.99	.20	.50	0.0	2.0	9.0	10.0
Target	0.0	.90	.10	.25	0.0	1.0	5.0	10.0
L. Bound	0.0	.80	.01	.10	0.0	.10	1.0	10.0

GOVERNMENT REJECTION TARGETS (TLSC' = $1,900,000)

Same as Contractor A except for MTBF = 325 hours

Contractor A's equipment item has an average unit production cost target (UC) of $50,000, a target MTBF of 500 hours, and a TLSC of $1,250,000 (see Figure 5). The remaining parameter targets corresponding to this TLSC are fraction of in-place repairs = 0.0, fraction of base repairs = .90, etc. In addition to his parameter targets, Contractor A has provided his estimate of the range of values that his equipment parameters may ultimately assume in the form of upper and lower bounds. These ranges are required to develop a meaningful assessment of Contractor and Government statistical risks.

The cost overrun value at which the Government wants to guarantee a high probability of equipment rejection in this example is TLSC' = $1,900,000. This "rejection target" is about 50% greater than Contractor A's target. It corresponds to repair level and manpower parameter targets identical to the Contractor's, but a decremented MTBF target of 325 hours. In other words, the Government would like to guarantee rejection in the case where Contractor A achieves an MTBF of only 325 hours while meeting all his remaining parameter targets.

Note that both the target and bounds for the depot man-hour figure (DMH) are 10 hours in Figure 5. This is due to the exclusion of the parameter, depot man-hours, from the set of parameters to be verified because the relatively low equipment NRTS rate would result in an extremely small number of depot repairs during the verification test period and hence, a statistically inadequate sample upon which to base an estimate of actual DMH.

RISK ASSESSMENT RESULTS

For these CMF parameter values and in particular a test period of 3,000 flying hours and a threshold factor of 1.25, the Contractor and Government statistical risks are reflected in Figure 6. The Contractor's probability of having his equipment rejected when he has actually met his TLSC ranges approximately from .23 to .32 with a most likely value of .28. The Government's probability of equipment acceptance when its rejection

22

target has been met ranges from .26 to .35 with a most likely value of .32. The existence of a range of risks for each party, as opposed to a single point risk, is a distinctive property of the LSCC. Its cause is the relative complexity of the CMF used for development of the TLSC and MLSC. The size of each risk range is partially a function of the estimated ranges for the repair level and man-hour parameters appearing in Figure 5. However, sensitivity analyses with the risk assessment model have shown that the sizes of the risk ranges are relatively insensitive to minor revisions in estimates of the parameter ranges that might occur during negotation of the LSCC terms and conditions.

FIGURE 6. RISK ASSESSMENT RESULTS
(Representative Case)

Contractor Risk = Pr(Govt. Rejects Equipment When Contractor
Target is Met) $\equiv \alpha$

$$\alpha \approx .28, \quad .23 \leq \alpha \leq .32$$

Government Risk = Pr(Govt. Accepts Equipment When Govt.
Rejection Target is Met) $\equiv \beta$

$$\beta \approx .32, \quad .26 \leq \beta \leq .35$$

Hence, the existence of risk ranges, though it may make the LSCC risk properties slightly more difficult to understand and interpret, does not constitute a serious weakness of the LSCC structure.

The size of the risks appearing in Figure 6 is another matter. These risks are high when viewed either in terms of their most likely values or their ranges, and would very likely be interpreted as unacceptable in a real-world setting. The reason for this is that eight parameters (MTBF, RIP, RTS, NRTS, PAMH, IMH, RMH, and BMH) are being verified simultaneously and the variabilities of the individual parameter estimates are combining through the CMF to produce a high variability in the MLSC. Since the concept of simultaneous verification of several logistics parameters is central to the application of

23

LSCCs, the likelihood of high risks is an intrinsic property of the LSCC when it is defined with respect to a single equipment item.

Experience with the risk assessment model suggests that in many cases, steps can be taken to reduce these risks with a minimal dilution of verification objectives. Two approaches are described in Figure 7. The first is to reduce the number of parameters to be verified. Verifying only MTBF instead of all eight logistics parameters in our example reduces Contractor risk (most likely value) from .28 to .22 and Government risk from .32 to .24. A variety of related strategies exists. One, for example, consists of verifying all eight parameters but defining two separate MLSCs: one (say $MLSC_1$) with MTBF being held constant at its target and the remaining seven being estimated, and the other ($MLSC_2$) with just the opposite configuration, and then defining MLSC as the average of $MLSC_1$ and $MLSC_2$. This strategy reflects a small reduction in verification potential to achieve much more favorable risk characteristics.

FIGURE 7. RISK ASSESSMENT RESULTS
(Alternative Approaches)

REDUCING THE SET OF PARAMETERS TO BE VERIFIED

- Same as Representative Case except only MTBF is subject to verification and all remaining parameters are assumed to achieve Contractor targets

- Contractor Risk = α $\approx$ .22(.28)

- Government Risk = β $\approx$ .24(.32)

INCREASING TEST LENGTH

- Same as Representative Case except T = 10,000 hrs. (3,000 hrs.)

- Contractor Risk = α $\approx$ .19(.28)

- Government Risk = β $\approx$ .20(.32)

Figure 7 also reflects the impact of increased test length in the case in which all eight parameters are verified. It shows that by increasing T from 3,000 hours to 10,000 hours, Contractor risk can be reduced from .28 to .19 and Government risk from

.32 to .20. This result illustrates the general fact that because of certain statistical properties of the CMF, dramatic increases in test length tend not to bring about commensurate reduction in risks. If a further risk reduction is desired, other changes can be explored, e.g., a change in the threshold factor (TF), a redefinition of the Government's rejection target (TLSC'), or even minor changes in the CMF.

AGGREGATION OVER SEVERAL ITEMS

A particularly notable property of the LSCC clarified by risk assessment model analyses is that statistical risks can be reduced by applying the LSCC to a group of items, in which case a single TLSC is developed for the aggregate of items instead of separate TLSCs for each individual item. Figure 8 illustrates this property. Suppose an LSCC is implemented with respect to the procurement of three items, all to be produced by the same contractor, and that the average unit costs and target MTBFs for the winning bidder, again called Contractor A, are as shown (where it is assumed for purposes of illustration that the remaining eight parameter targets for all three items are identical to those used in the original single item example in Figure 5).

If a TLSC were defined for the first item only, the Contractor risk would be .28 (most likely value of range) and the Government risk, assuming a rejection target of TLSC' = 1.5 x TLSC (resulting, again, only from a decremented MTBF) would be .32.

FIGURE 8. AGGREGATION UNDER THE LSC COMMITMENT

AGGREGATION REDUCES STATISTICAL RISKS

- Item 1: UC = $ 50,000, MTBF = 500 hrs.: α = .28, β (1.5 x TLSC) = .32
- Item 2: UC = $ 75,000, MTBF = 250 hrs.: α = .22, β (1.5 x TLSC) = .26
- Item 3: UC = $100,000, MTBF = 150 hrs.: α = .17, β (1.5 x TLSC) = .21
- Items 1, 2, and 3 in Aggregate: α = .10, β (1.5 x TLSC) = .10

Figure 8 shows similar results for Items 2 and 3, assuming individual targets and the same threshold factor, TF = 1.25, in each case. The progressively lower risks result from an increasing ratio of test period length (again, 3,000 hours) to MTBF, which reflects the

likelihood of more failures being verified and consequently, *increasing statistical* confidence.

Figure 8 indicates that by summing the targeted LSCs for the three items and defining the formal commitment TLSC in terms of this sum, a rather dramatic reduction of both Contractor and Government risks to .1 is achieved. The cause of this reduction is the existence of statistical independence of verification test data among items. This independence has a smoothing effect on the MLSC.

The property of reduced risk under aggregation is noteworthy and suggests that use of the LSCC should be given serious consideration as an LSC reducing mechanism in procurements where the possibility of cost aggregation exists. However, two caveats should be noted. The first deals with the passing down of LSCC provisions from the Prime Contractor to his subcontractors. Suppose an LSCC is implemented with respect to an aggregate of items under a prime contract and risk analyses indicate that the negotiated threshold factor and test length reflect acceptably low risks to both the Government and the Prime Contractor. Considerable caution should be used by the Prime if he passes down essentially the same form of LSCC provision on an item-by-item basis to his subs. If subcontract remedies or price adjustments are based on the same threshold factor and test length, subcontract statistical risks may be prohibitively high. The likelihood of this occurrence may call for substantial modification of LSCC structure at the subcontract level, e.g., a provision for additional verification testing of certain items at the expense of the Prime Contractor.

The second caveat deals with the masking of bad reliability and maintainability performance of individual items. When an LSCC is implemented in the aggregate, it is possible that one or two items will have exceptionally high measured LSCs during the verification test, but the aggregate target will still be met due to the offsetting effect of low measured LSCs for the remaining items. From the point of view of cost, such an

occurrence does not reflect a problem, since the Government's primary concern is with aggregate LSC and the LSCC has presumably shown whether the aggregate cost target has or has not been met.

But this possibility may reflect a serious problem from the point of view of total weapon system readiness, since the one or two poor performing items, while not causing prohibitively high aggregate LSC, may ultimately be prime causes of weapon system down time in the field. There are no simple solutions to this problem. One possible alternative is the use of a contractual target on readiness at the weapon system level in conjunction with an aggregate LSCC. Such a set of dual macro targets, if they could be unambiguously defined, would have the effect of controlling aggregate costs of support resources utilized while preventing the logistics performance of any one item from getting too far out of line. The formulation of system level targets on readiness that functionally incorporate subsystem performance is not an easy task, however, and requires further research.[16]

RISK ASSESSMENT IN STRUCTURING AND MANAGING THE LSC COMMITMENT

The risk assessment procedures discussed in this chapter provide the Government with a powerful new tool to reduce the life cycle costs of military hardware. They add considerable substance to the concept of the LSCC and their development has numerous implications for the structuring and management of the LSCC.

Research and LSC Commitment Structuring

The risk assessment procedures can be used to develop LSCC structures that maximize Contractor incentive to reduce real Government incurred LSCs while

---

[16]In development of the numerical results for the example reflected in Figures 4 through 8 above, it was assumed that the ultimate equipment unit cost had not been changed from its target value (UC) by the Contractor. In most recent LSCC applications, however, unit cost has been subject to change by the Contractor, i.e., he has been able to include it as one of his trade-off parameters. The effect of this is to complicate the assessment of LSCC risks. This statistical problem can be substantially ameliorated by redefining the target unit price (UC) as a ceiling price and hence permitting only reductions in unit price in Contractor trade-off analyses subsequent to negotiation of the TLSC.

maintaining statistical risks to Contractor and Government at acceptable levels. For example, the impact of alternative CMFs on the relationships among the control parameters (α, β, T and TF) can be assessed in a rigorous manner. This capability can pave the way for development of CMFs which adequately represent the costs of actual equipment demands for logistic support resources while reflecting (1) minimal risks to Contractor and Government, (2) a threshold factor (TF) value which is acceptable in the contract negotiating environment, and (3) a test length (T) value that is realistic vis-a-vis using command objectives and operating constraints. The procedures can also be used in this experimental mode to isolate those classes of equipment which, due to the nature of their demands on supply and maintenance resources, would be particularly well suited for use of the LSCC. For example, experimentation to date suggests that equipments exhibiting relatively lower unit costs or requiring fixed-length overhaul intervals tend to result in lower statistical risks.

Setting the Control Parameters in a Contracting Environment

Having developed an explicit relationship among the four control parameters of the LSCC, we can now make some significant observations regarding how these parameters should be set in a real-world contracting environment. It would be desirable to be able to determine values for all four parameters during development of the request for proposal (RFP) for subsequent inclusion in it. This would permit extensive studies of trade-offs among the four parameters by Government personnel. Furthermore, it would provide both Government and Contractor with time to study the LSCC statistical risk characteristics prior to negotiation of detailed terms and conditions of the LSCC.

Such a prior determination of control parameter values cannot be made, however, because precise assessments cannot be generated until the Contractor's targets for all parameters to be verified are known. In other words, various risk properties of the LSCC naturally differ from one bidder to the next. Consequently, only preliminary estimates of

risk characteristics based on Government assessment of industry capabilities and experimental runs of the risk assessment model can be undertaken prior to receipt of bidders' proposals. In view of this constraint, a possible scenario for determination of parameters is described as follows:

Step 1: An upper bound on α = Contractor risk is incorporated by the Government in the RFP as a guaranteed condition of the LSCC.

Step 2: Each bidder submits a TLSC with targets for parameters to be verified as part of his proposal and the Government selects a source for equipment development and production.

Step 3: Subsequent to contract award, the Government inserts the winning bidder's parameter targets and Government rejection targets into the risk assessment model and trades off test length (T), threshold factor (TF), and β = Government risk subject to the upper bound on α, until a set of control parameter values that minimizes expected LSCC costs to the Government is found.

This scenario provides an explicit limit on statistical risk to the Contractor well in advance of negotiation of detailed terms and conditions of the LSCC, while, at the same time, attempting to provide maximum flexibility to the Government in its search for a minimum expected cost position.[17]

CONCLUSIONS

The study findings lead to several broad observations:

- The use of a simplified cost model framework as a basis for logistics targets and measurements provides a mechanism for focusing Contractor design efforts on equipment characteristics affecting failure rates and repair requirements commensurate with the

---

[17]This scenario is similar in certain important respects to the method by which reliability tests are currently incorporated in electronic hardware procurements. In this case, a specific test plan as defined by α, β, and the discrimination ratio, θ_0/θ_1 (analogous to the ratio, TLSC'/TLSC) is usually incorporated in the hardware contract prior to or during contract negotiations via MIL-STD-781B. A test length (T) is not specifically mentioned because the test is sequential in nature and hence, the ultimate value of T required to guarantee the pre-specified α and β values depends on the information content in the stream of test data values.

relative impacts of these characteristics on LSCs. However, the framework must be developed with care to ensure that it summarizes these cost impacts accurately while simultaneously being simple enough to be interpreted without confusion in a contracting environment.

- Analytical techniques developed in this study can be used to assess trade-offs among alternative LSC Commitment model frameworks, risks, thresholds, and test lengths. Through this analysis, those LSC Commitment configurations that most effectively convey Government LSC reduction goals to the Contractor can be found.

- The simultaneous verification of several logistics parameters in the operational environment called for by the LSC Commitment tends to result in either high statistical risks to Contractor and Government or unacceptably long field verification test periods. The technique of applying the LSC Commitment with respect to an aggregation of equipment items results in reduced risks, and hence may provide a workable solution to this problem. But the technique has the potential drawback of masking poor logistics performance of a small number of equipment items in the aggregation. While this attribute is not a matter of primary concern from the standpoint of aggregate LSC expenditures, it may contribute to reduced visibility of logistics performance impacts on weapon system readiness.

- The LSC Commitment is an innovative contracting technique. It embodies the appealing concept of a macro target to summarize aggregate costs and transmit multiple incentives to the Contractor. However, because it has been used in only a small number of contracts to date, the LSC Commitment's effectiveness as a contracting and management tool requires continued evaluation. Future applications should be on a selective and controlled basis.

REFERENCES

1. Betaque, Norman E., Jr. "An Evaluation of the Logistics Support Cost Model" (WN 7501-2). Washington, D.C.: Logistics Management Institute, August 1975 (unpublished working note).

2. Collins, Dwight E. Analysis of Statistical Risk in the Use of Logistic Support Cost Commitments. Washington, D.C.: Logistics Management Institute (forthcoming report).

3. Concepts and Analysis Directorate, Acquisition Logistics Division, Air Force Logistics Command. Logistics Support Cost Model User's Handbook, ALD/XRSC. Dayton: Wright-Patterson AFB, August 1976.

4. Departments of the Army, the Navy, and the Air Force. Joint Design-to-Cost Guide: Life Cycle Cost as a Design Parameter (DARCOM P700-6, NAVMAT P5242, AFLCP/AFSCP 800-19). 11 June 1976.

5. Directorate of Defense Research and Engineering. Department of Defense Directive 5000.28, "Design to Cost." 23 May 1975.

6. Kernan, John E., Jr. and Menker, Lavern J., Joint AFSC/AFLC Commanders' Working Group on Life Cycle Cost, ASD/ACL. Life Cycle Cost Procurement Guide. Dayton: Wright-Patterson AFB, July 1976.

7. Luce, R. Duncan and Raiffa, Howard. Games and Divisions. New York: John Wiley & Sons, 1964.

8. Office of the Assistant Secretary of Defense (Comptroller). Department of Defense 7110.1-M, "Department of Defense Budget Guidance Manual," 15 June 1973.

9. Van Horne, James C. Financial Management and Policy. Englewood Cliffs: Prentice-Hall, 1968.

APPENDIX A

LSC MODEL PARAMETER DEFINITIONS

BLR   -   the base labor rate ($/man-hour) (G)*

BMH   -   the average number of man-hours to perform intermediate level (base shop) maintenance on a removed item including fault isolation, repair, and verification (C)

BMR   -   the base consumable material consumption rate (including minor items of supply such as nuts, washers, rags, etc., which are consumed during repair of the item) (G)

BRCT   -   the average base repair cycle time in months, i.e., the elapsed time for a RTS item from removal of the failed item until it is returned to base serviceable stock (G)

DLR   -   the depot labor rate ($/man-hour) (G)

DMH   -   the average number of man-hours to perform depot-level maintenance on a removed item including fault isolation, repair, and verification (C)

DMR   -   the depot consumable material consumption rate (analogous to BMR) (G)

DRCT   -   the average depot repair cycle time in months, i.e., the elapsed time for a NRTS item from removal of the failed item until it is made available to depot serviceable stock (G)

EBO   -   the maximum allowable expected number of unfulfilled demands for a given LRU at the base at any point in time (G)

IMH   -   the average number of man-hours to perform corrective maintenance of the item in place or on line including fault isolation, repair, and verification (C)

M   -   the number of operating locations (G)

MTBF   -   the mean time between failures in operating hours of the item in the operational environment (C)

NRTS   -   the fraction of removed items expected to be returned to depot for repair (= 1 - RTS) (C)

OS   -   the fraction of the total force deployed to overseas locations (G)

*Note: G -   supplied by the Government
        C -   supplied by the Contractor
        M -   computed by the model

OSTCON – the average order and shipping time within the CONUS (G)

OSTOS – the average order and shipping time to overseas locations (G)

PAMH – the average number of man-hours expended in place on the complete system for preparation and access of the item; for example, jacking, unbuttoning, removal of other units, and hookup of support equipment (C)

PFFH – the peak force flying hours, i.e., the expected total fleet flying hours for one month during the peak usage period (G)

QPA – the quantity of like items within the parent system, i.e., "quantity per application" (C)

RIP – the fraction of item failures which can be repaired in place or on line (C)

RMH – the average number of man-hours to isolate a fault, remove and replace the item, and verify restoration of the system to operational status (C)

RTS – the fraction of removed items expected to be repaired at the base (= 1 – NRTS) (C)

STK – the stock level of the item at each base (M)

TFFH – the expected total force flying hours over the program inventory usage period (the projected life of the item) (G)

UC – the negotiated unit cost of a spare item as of the end of the verification test (C)

UF – the ratio of operating hours to flying hours for the item (C)

APPENDIX B

GLOSSARY OF ACRONYMS

α -   the probability of getting an MLSC value that suggests rejection of the Contractor's equipment when in reality, MMLSC is less than or equal to the target

β -   the probability of getting an MLSC value that suggests acceptance of the Contractor's equipment when he has actually overrun his target to the extent that MMLSC = TLSC' (where TLSC' > RT)

CMF   -   cost model framework

COD   -   correction of deficiencies

CV   -   coefficient of variation

DTC   -   design-to-cost

ECP   -   engineering change proposal

LCC   -   life cycle cost

LRU   -   line replaceable unit

LSC   -   logistic support cost

LSCC   -   logistic support cost commitment

MLSC   -   measured logistic support cost

MMLSC   -   the true underlying LSC value estimated by the MLSC

NOI   -   net operating income

O&S   -   operating and support

RFP   -   request for proposal

RIW   -   reliability improvement warranty

R&M   -   reliability and maintainability

RT   -   the remedy threshold, i.e., an MLSC threshold (> TLSC) above which a contract remedy or downward price adjustment is required

SE   -   support equipment

T   -   the length of the verification test period in total weapon system operating hours

TF   –   the threshold factor (> 1) relating RT to the TLSC

TLSC –   the Contractor's target logistic support cost

TLSC' –   the Government's "rejection target," a specified value of MMLSC, greater than RT, at which the Government wants to ensure a high probability of equipment rejection

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Logistic Support Cost Commitments for Life Cycle Cost Reduction		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER LMI Task 75-1/5
7. AUTHOR(s) Dwight E. Collins		8. CONTRACT OR GRANT NUMBER(s) SD-321
9. PERFORMING ORGANIZATION NAME AND ADDRESS Logistics Management Institute 4701 Sangamore Road Washington, D. C. 20016		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics)		12. REPORT DATE June 1977 13. NUMBER OF PAGES 43
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

"A" Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Cost Verification, Design to Cost, Life Cycle Cost, Logistic Support Cost Commitment, Measured Logistic Support Cost, Operating and Support Costs, Reliability and Maintainability, Statistical Risk, Statistical Uncertainty, Support Cost Guarantee, Target Logistic Support Cost

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In its efforts of recent years to reverse the trend of increasing operating and support (O&S) costs of weapon systems and equipment, the Department of Defense (DoD) has begun to use several new contracting techniques to transmit Government cost reduction goals to the Contractor during equipment development and production. One of these techniques is the Logistic Support Cost (LSC) Commitment. The LSC Commitment has three primary elements: (1) a target logistic support cost (TLSC) defined in terms of a cost model framework, (2) a field verification test procedure, and (3) a contract remedy or price adjustment based on verification test results.

This report summarizes results of a recent study which investigates the incentives conveyed by the LSC Commitment and the risks accompanying its implementation. It focuses particularly on the impact of statistical risk on the interpretation of verification test results, and presents guidance for structuring future LSC Commitments.

The study has led to the following observations:

- The use of a simplified cost model framework as a basis for logistics targets and measurements provides a mechanism for focusing Contractor design efforts on equipment characteristics affecting failure rates and repair requirements commensurate with the relative impacts of these characteristics on LSCs. However, the framework must be developed with care to ensure that it summarizes these cost impacts accurately while simultaneously being simple enough to be interpreted without confusion in a contracting environment.

- Analytical techniques developed in this study can be used to assess trade-offs among alternative LSC Commitment model frameworks, risks, thresholds, and test lengths. Through this analysis, those LSC Commitment configurations that most effectively convey Government LSC reduction goals to the Contractor can be found.

- The simultaneous verification of several logistics parameters in the operational environment called for by the LSC Commitment tends to result in either high statistical risks to Contractor and Government or unacceptably long field verification test periods. The technique of applying the LSC Commitment with respect to an aggregation of equipment items results in reduced risks, and hence, may provide a workable solution to this problem. But the technique has the potential drawback of masking poor logistics performance of a small number of equipment items in the aggregation. While this attribute is not a matter of primary concern from the standpoint of aggregate LSC expenditures, it may contribute to reduced visibility of logistics performance impacts on weapon system readiness.

- The LSC Commitment is an innovative contracting technique. It embodies the appealing concept of a macro target to summarize aggregate costs and transmit multiple incentives to the Contractor. However, because it has been used in only a small number of contracts to date, the LSC Commitment's effectiveness as a contracting and management tool requires continued evaluation. Future applications should be on a selective and controlled basis.