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ELECTRONIC SYSTEMS DIVISION
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An interactive Life Cycle Cost (LCC) mathematical model with a built-in Sensitivity Analysis capability has been developed for use in the evaluation of proposed designs for the Air Force SEEK IGLOO Radar System.

The SEEK IGLOO LCC Model consists of 10 cost elements which describe acquisition costs as well as operation and support costs. This volume presents the equations for

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these cost elements. Also included is a full discussion of the assumptions made which impact the development of these cost element equations.

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Dr. Melvyn P. Galin, and Ava E. Schutzman, of MITRE, and Capt. Freeland K. Abbott, Jr., of AFALD/AQE, were involved in the early definitional phase of SEEK IGLOO LCC. A preliminary version of the LCC Model equation structure was drafted by Capt. Abbott.

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PREFACE

The SEEK IGLOO Life Cycle Cost (LCC) Model is presented in three volumes, each of which serves a unique function and addresses a specific audience. Volume I, Cost Element Equations, presents a discussion of the accounting model which is used to estimate the LCC of any proposed SEEK IGLOO Radar System. This volume presents the equations for the ten Cost Elements which comprise the accounting model. Also included is a full discussion of the assumptions concerning the acquisition, operation, and logistics support of the proposed radar system which had an impact on the development of the Cost Element equations. The intended audience of Volume I is the cost analyst who is interested in a discussion of the various Cost Element equations which comprise this accounting model.

Volume II, the User's Manual, presents all the information necessary to run the computerized LCC Model effectively. Included in this volume are (1) instructions for preparing the necessary data input files, (2) an explanation of the use of the interactive capability, (3) a discussion of how to interpret the output, and (4) a complete presentation of the built-in Sensitivity Analysis capability of the LCC Model. In addition, in order to make Volume II a stand-alone document, a full discussion of the Cost Element Equations (Volume I) is included as an appendix. Thus, Volume II is both a necessary and sufficient tool for utilizing the LCC Model to compute the LCC of a proposed SEEK IGLOO Radar System design.

Volume III, the Maintenance Manual, was written for the programmer who must maintain or possibly modify the FORTRAN code of the LCC Model. It contains a complete discussion of the structure, conventions, subroutines, etc., of the LCC Model computer program. A complete listing of the FORTRAN code, which contains extensive internal comments, is included in the Maintenance Manual.

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SECTION 1

INTRODUCTION

1.1 Purpose of the Model

An interactive Life Cycle Cost (LCC) mathematical model with a built-in Sensitivity Analysis capability has been developed for use in the evaluation of proposed designs for the Air Force SEEK IGLOO Radar System.

The purpose of the Air Force SEEK IGLOO Program is to upgrade the radars at the thirteen radar stations performing surveillance for the Alaskan Air Command. In particular, these radars are to be upgraded so as to be minimally attended. For a discussion of the history of the SEEK IGLOO Program and the technical requirements of the upgraded radars, the reader is referred to the SEEK IGLOO System Specification.

The SEEK IGLOO Life Cycle Cost (LCC) Model was developed for the SEEK IGLOO Program by The MITRE Corporation. This LCC Model consists of two main components. The first component consists of an analytical accounting cost model which computes the LCC of any proposed SEEK IGLOO Radar System. This accounting model is a systematic way of adding up component costs via a set of equations which model the development, production and support costs of the radar system. The accounting model implemented is an adaptation to the SEEK IGLOO Radar System of the basic AFLC Logistics Support Cost Model. The second component of the LCC Model provides sensitivity analysis computations as an aid in trade-off considerations during radar system design.

The SEEK IGLOO Life Cycle Cost (LCC) Model is an adaptation of the basic Logistics Support Cost (LSC) Model* for the SEEK IGLOO Program. A modification of the LSC Model was chosen because the LSC Model is well known and accepted as an estimator of operation and support costs. Required use of the SEEK IGLOO Model by Contractors is indicative of the Government's concern with the long range support cost aspects of the program as well as the more immediate acquisition costs.

The SEEK IGLOO LCC Model serves the following purposes: (1) It identifies the life cycle cost drivers which are under Contractor control. (2) It illustrates the life cycle cost impact of design decisions. (3) It illustrates the life cycle cost impact of proposed modifications to the baseline maintenance concept. (4) It illustrates the life cycle cost impact of engineering change proposals (ECPs).

1.2 Cost Elements

The SEEK IGLOO LCC Model consists of ten cost elements which describe acquisition costs as well as operation and support costs of the SEEK IGLOO system. Acquisition costs exclusive of identifiable unit costs of peculiar support equipment are highly aggregated in the model and will not be computed from detailed calculations. For example, the cost of prime mission equipment is to be taken directly from the offeror's proposal and entered into the model as a total. The remaining cost elements require input data at a breakdown sufficiently detailed so as to be useful in evaluating the validity of other costs estimated by the LCC Model, such as maintenance costs, spares costs, and support equipment costs.

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*Logistics Support Cost Model, User's Handbook, Headquarters AFLC/AQMLE, June 1975.

The ten cost elements of the SEEK IGLOO LCC Model are as follows:

1. Development and Production
2. Maintenance (Labor and Transportation)
3. Investment Spares
4. Replenishment Spares
5. Consumables
6. Support Equipment
7. Facilities
8. Training
9. Inventory Management
10. Software Maintenance

The above list includes virtually all the cost elements which are considered significant in terms of possible differences among Contractors' SEEK IGLOO designs.

Equations describing operation and support costs are detailed to the level of the line replaceable unit (LRU)*, with sufficient flexibility to fit Contractors' maintenance designs ranging from maximum repair on site to remove-and-replace on site with repair at either a central maintenance facility (CMF) or the depot. Provision is incorporated for LRU discard-on-failure actions taken at the sites, the CMF, or the depot.

In addition to calculation of life cycle costs, the SEEK IGLOO LCC Model will compute the total manhours expended in maintenance at the site level, per site per year. This calculation will be included

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*Defined as per the SEEK IGLOO System Specification, Paragraph 3.5.1.1.

to facilitate verification by the Government and Contractors that proposed designs meet the specification limit of 1300 manhours per site per year.*

A listing of general assumptions inherent in the SEEK IGLOO LCC Model is provided in the following section. Notes on more specific assumptions and justification for formulation are to be found in the sections on the relevant cost elements. The terms used in the equations are generally defined only the first time that they appear.

1.3 General Assumptions

1. SEEK IGLOO is a program to acquire 13 minimally-attended radars, installed at prescribed radar sites, one hot mock-up radar, and an integrated logistics support system. The radars are to employ current technology, and hence, performance reliability and maintainability projections are assumed known to the level of the line replaceable unit (LRU).
2. Failures are assumed to follow an exponential distribution over the twenty year system life.
3. It is assumed that the user of the LCC Model will know or have estimates for repair levels (discard on failure, repair at site, repair at central maintenance facility, repair at depot) of the components involved, to the level of the LRU.
4. There will be three levels of repair (exclusive of condemnation): repair on site, repair at the central maintenance facility or CMF (Elmendorf AFB), repair at the depot (Sacramento ALC). From each site only two levels can be exercised: repair on site vs. ship to the CMF. From the CMF only two

*As per the SEEK IGLOO System Specification, Paragraph 3.5.1.4.

levels can be exercised: repair at the CMF vs. ship to the depot. (The decision to ship failed LRUs to the depot is made at the CMF upon receipt and inspection of the equipment.) Excluding items designated for depot repair, there will be two levels of condemnation: condemn at site, or ship to the CMF and condemn there.

5. Radar sites are assumed to be identical in the LCC Model, with respect to maintenance manpower levels and consumables.

6. Radar sites are assumed to be identical in the LCC Model with respect to facilities. (E.g., for any given system design run through the model, all sites must employ old radomes or new radomes simultaneously.)

7. Radar sites are assumed to be identical with respect to environmental effects on equipment failure rates and logistics support. (E.g., although peculiarities and variances exist among the 13 radar sites, most notably the impact of weather on stocking requirements and availability of logistics support, these will be averaged out in the description of a radar site for the LCC Model.)

8. In the LCC Model, inventories of spare LRUs will be located at each of the radar sites, consistent with the demand rate for LRUs attended to at sites, and the regular CMF-to-site resupply time interval selected by the Government for use in the model. In addition, inventories will also be located at the CMF (Elmendorf AFB) and the depot (Sacramento ALC) consistent with the appropriate LRU demand rates, resupply times, CMF repair cycle time, and depot repair cycle time selected for use in the model.

9. Forward supply points are not considered by the LCC Model. Moreover, the regular resupply time interval for sites supplied via forward staging points is assumed identical with that for sites served directly.

10. The SEEK IGLOO LCC Model allows for one hot mock-up radar in addition to the 13 minimally-attended radars at the sites. Maintenance costs, replenishments and consumables for the hot mock-up radar are omitted from the model.

11. The Contractor may identify an LRU type as "mission-critical". This choice may be based on the probability that failure of such an LRU would result in system downtime of unacceptable length, or may be based on a tradeoff analysis against the cost of emergency resupply, or both. The LCC Model includes a special provision to offer a tradeoff capability on whether mission-critical LRUs be stocked no less than one per site regardless of cost. The cost of such stock is included in investment spares cost.

12. Transportation costs may vary for the 13 radar sites, but a representative average will be employed in the LCC Model. The cost of regular resupply transportation to the sites, a portion of which is legitimately a component of life cycle cost when employed in logistics support, will be excluded from the LCC Model. This kind of transportation will appear as free to the model users (Contractors) for tradeoff studies.

13. The LCC Model includes the cost of unscheduled emergency intermediate level maintenance dependent upon Contractor-provided parameters. However, the model omits the cost of priority resupply (both transportation and personnel costs)

initiated by stockout and subsequent system failure occuring in between regular resupply runs. This cost is omitted because the calculation of the probability of a priority resupply run in any given week, year, etc., is primarily dependent on Air Force-provided stockout parameters and is difficult to estimate due to integer roundoff of stocking levels.

14. Maintenance costs computed include the costs of labor for both corrective (unscheduled) and preventive (scheduled) maintenance, and the cost of transportation for preventive maintenance. The LCC Model allows for a variable number of dedicated maintenance personnel per radar site (but not to exceed 3 per site*), and costs are computed on the basis of dedicated personnel at the sites. Maintenance labor costs at the CMF and at the depot are computed on the basis of actual maintenance labor time incurred. Preventive maintenance cost calculations allow the option for use of site personnel or CMF personnel (in which case the model includes their TDY costs and cost of their transportation to the sites).

15. The preventive maintenance concept is modeled so that Contractor-provided data may dictate that CMF personnel travel to the radar sites. The modeled concept does not include preventive maintenance whereby LRUs are returned to the CMF or to the depot for further expenditures of inventories, labor, or materials.

16. The SEEK IGLOO LCC Model calculates the total manhours expended in maintenance at the site level, per site per year, and internally verifies that proposed designs meet

*As per the SEEK IGLOO System Specification, Paragraph 3.5.1.1.

the specification limit of 1300 manhours per site per year.* The following further assumptions apply: (i) The 1300 manhours per site per year limit is independent of the number of maintenance personnel designated per site. (ii) Off-equipment site maintenance manhours, and maintenance performed by CMF personnel at the radar sites, are specifically excluded from the 1300 manhours limitation.

17. The LCC Model assumes that all maintenance personnel at a given site have the same skill and need the same training. In particular, maintenance personnel at the radar sites will be at "Level #1", equivalent to AF Skill Level 5. At Elmendorf, maintenance personnel will be at "Level #2", equivalent to AF Skill Level 7.** The LCC Model assumes no organic (i.e., military or in-service civilian) maintenance of SEEK IGLOO radar other than at Sacramento ALC.

18. Training costs for SEEK IGLOO are computed according to the following concept: The Contractor will train a cadre of personnel from the AAC radar squadron at Elmendorf AFB. This cadre will perform subsequent training of personnel for site and CMF maintenance. This cadre will also perform the depot level training. Initial training is considered to be completed in the first year of SEEK IGLOO system operation. Recurring training costs for site, CMF and depot personnel are based on turnover rates. Recurring training costs for new cadre personnel are absorbed in their yearly salaries over the lifetime of the system.

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*As per the SEEK IGLOO System Specification, Paragraph 3.5.1.4.

**As per the SEEK IGLOO System Specification, Paragraphs 50.1 and 50.2.

19. Software maintenance will be performed only at depot level (Sacramento ALC). The model user (Contractor) may include the one-time cost of a software maintenance facility, if one is intended to be used. The LCC Model does not include provision for recurring management costs associated with the software maintenance facility. Transportation and personnel costs associated with the distribution of new software from the depot to the CMF (Elmendorf AFB), and thence to the radar sites, are also omitted.

20. There will be no special provision in the SEEK IGLOO LCC Model for the costs of non-maintenance support personnel, their support facilities (barracks, heat, food, etc.), nor for any cost related to the communications system which will support the SEEK IGLOO Minimally-Attended Radar system.

21. All costs input to or computed and output from the SEEK IGLOO LCC Model are in constant-year (now-year) dollars.

SECTION 2

THE COST ELEMENT EQUATIONS

2.1 Development and Production

The Cost Element for Development and Production derives from highly aggregated "lump-sum" inputs. These inputs are derived from total contract costs to the Government for the Validation (Phase I) and Full-Scale Development (Phase II) phases of the SEEK IGLOO program, and from Contract Work Breakdown Structure (CWBS) elements for the Production phase (Phase III). In each case, inputs are to represent the most recent data on these costs (estimates, negotiated values or actual values) and must agree with corresponding proposed or contracted costs. Incentive fees shall be included as applicable.

The cost of development and production is C_1 in the SEEK IGLOO LCC Model, computed from the formula:

$$C_1 = VAL + FSD + (PME)(XUC) + REFURB + SW + PRODX$$

where

VAL = total contract cost to the Government for Phase I (Design Validation)

FSD = total contract cost to the Government for Phase II (Full-Scale Development)

PME = Phase III CWBS, level 2 item "Prime Mission Equipment", covering all (12) production systems (including learning-curve effects), and excluding level 3 items "Software" and "Refurbishment"

XUC = dummy cost adjustment factor (see discussion below); nominal value 1.0

REFURB = Phase III CWBS level 3 item "Refurbishment" covering refurbishment of 2 preproduction options

SW = Phase III CWBS level 3 item "Software" covering 12 production systems

PRODX = sum of all Phase III CWBS level 2 items <u>excepting</u> "Prime Mission Equipment," "Training," "Support Equipment," and "Initial Spares and Repair Parts."

Note that costs associated with Phase III CWBS level 2 items "Training," "Support Equipment," and "Initial Spares and Repair Parts," will be obtained analytically through other equations in the SEEK IGLOO LCC Model.

The dummy variable XUC is provided to facilitate LCC trade-offs involving any factors (such as the use of high-reliability parts throughout the design) which can be shown to multiply baseline costs of all LRUs and PME by a single constant. The same dummy variable is included in the Investment Spares and Replenishment Spares cost elements. The value of XUC must be set at unity (1.0) in any runs of the model whose outputs correspond to proposed or contractual baseline costs.

For sensitivity calculations only, it is implied internally within the model that PME increases with UC_i (unit cost of LRU type i) at the rate

$$d\ PME/d\ UC_i = (M - 1)\ (QPA_i)$$

where

M = number of radar sites (13)

QPA_i = number of LRUs of type i in each radar.

2.2 Maintenance (Labor and Transportation)

The Cost Element for Maintenance (Labor and Transportation) includes costs associated with both corrective (unscheduled) and preventive (scheduled) maintenance.

This cost element is comprised of five principal components. The first component calculates the life cycle cost of the dedicated maintenance personnel at the sites. The second part covers the maintenance labor costs incurred at the central maintenance facility or CMF (Elmendorf AFB). The third part computes maintenance labor costs incurred at the depot (Sacramento ALC). The fourth component calculates the cost of emergency corrective maintenance trips by CMF personnel to the radar sites. The fifth component calculates the cost for preventive maintenance trips by CMF personnel to the sites.

The LCC Model allows for a variable number of dedicated maintenance personnel per radar site (but not to exceed 3 per site*) at "Level #1", equivalent to AF Skill Level 5. At Elmendorf, maintenance personnel will be at "Level #2", equivalent to AF Skill Level 7.** The LCC Model assumes no organic (i.e., military or in-service civilian) maintenance of SEEK IGLOO radar other than at Sacramento ALC.

The structure of the equations for this cost element is based upon the following maintenance concept: Every LRU has a known repair level (RL), selected from one of the following:

- discard on failure (RL=0)
- repair at site (RL=1)
- repair at CMF (RL=2)
- repair at depot (RL=3)

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*As per the SEEK IGLOO System Specification, Paragraph 3.5.1.1.

**As per the SEEK IGLOO System Specification, Paragraphs 50.1 and 50.2.

LRUs with RL=0 are condemned at the radar sites. For LRUs with RL=1 repair is attempted at site.* If not possible, the LRU is sent to the CMF for bench check and repair (or condemnation there). LRUs with RL=2 or 3 are always sent to the CMF. At the CMF, LRUs with RL=3 are sent to the depot.

Thus, the cost C_2 of maintenance is computed using the formula below:

$$C_2 = M(NSP)(YSLR)(PIUP)$$

$$+ M \cdot \sum_{i=1}^{N} \frac{(PIUP)(YOH)K(QPA_i)(1-RIP_i)}{MTBI_i} \times \Big\{ [(1+FPR_i)(SNRTS_i)(CBCMH_i)$$

$$+ (CRTS_i)(CMH_i) + (FPR_i)(COND_i)(CBCMH_i)](CLR)$$

$$+ [(DCOND_i + DRTS_i)(DBCMH_i) + (DRTS_i)(DMH_i)](DLR) \Big\}$$

$$+ M(PIUP)(YOH)K[(CCMP)(ADCM)(CDR) + H] \cdot \left\{ \sum_{i=1}^{N} \frac{(MCF_i)(QPA_i)(1-RIP_i)}{MTBI_i} + \frac{(1-DS)}{SMTBI} \right\}$$

$$+ \frac{M(PIUP)(YOH)}{CPMI} [(CPMP)(ADPM)(CDR) + H]$$

* The "baseline" maintenance concept (as per the SEEK IGLOO System Specification, Paragraph 3.5.1) emphasizes remove-and-replace actions rather than LRU repair at the radar sites. The option for site repair (RL=1) is offered in the SEEK IGLOO LCC Model for exploration among maintenance concepts, in the interest of reducing life cycle cost. However, formal use of the SEEK IGLOO LCC Model to meet a Government obligation must take into consideration whether departure from the baseline maintenance concept is justified. Offerors are referred to the Instructions for Proposal Preparation.

where

M = number of radar sites (13)

NSP = number of radar maintenance personnel per radar site

YSLR = yearly labor rate for site radar maintenance personnel

PIUP = number of operating years of the system (20)

N = number of different LRU types within the system

YOH = yearly operating hours of the system (8766)

K = the reliability factor which converts predicted failure rates (incident rates) to operational failure rates (incident rates)

QPA_i = number of LRUs of type i in each radar

RIP_i = fraction of incidents (maintenance actions) of LRU type i which are met by repair in place

$MTBI_i$ = mean time between incidents (maintenance actions) for LRU type i, in hours

FPR_i = false pull rate for LRU type i, i.e., that multiple of failed LRUs which are removed but haven't failed (in most part this factor is to allow for the inability of fault isolation to a single LRU). (Thus (# of removed LRUs)=$(1+FPR_i)$(# of failed LRUs).)

$COND_i$ = fraction of failed (and removed) LRUs of type i which are condemned at the site. (Here we only allow either $COND_i=0$ or $COND_i=1$, depending on the repair level RL_i which is input)

$SRTS_i$ = fraction of failed (and removed) LRUs of type i which are repaired at the site

$SNRTS_i = 1 - SRTS_i - COND_i$ = fraction of failed (and removed) LRUs which are sent to the CMF for possible repair

$CBCMH_i$ = average manhours at the CMF to perform a shop bench check, screening and fault verification of a removed LRU. (This time is assumed to be the same for a falsely pulled LRU as for a failed LRU.)

$CRTS_i$ = fraction of failed (and removed) LRUs of type i which are repaired at the CMF

CMH_i = average manhours to perform corrective maintenance on a failed LRU of type i, including fault isolation, repair and verification

CLR = hourly labor rate at the CMF

$DCOND_i$ = fraction of failed (and removed) LRUs which are condemned at the depot, due to wear-out

$DRTS_i$ = fraction of failed (and removed) LRUs which are repaired at the depot

$DBCMH_i$ = average manhours at the depot to perform a shop bench check, screening and fault verification of a removed LRU

DMH_i = same as CMH_i, except refers to depot repair

DLR = hourly labor rate at the depot

CCMP = average number of CMF personnel required for an emergency corrective maintenance trip to a radar site

ADCM = average number of days required to complete an emergency corrective maintenance trip to a radar site, from the time of leaving the CMF until return to the CMF

CDR = daily rate for CMF personnel TDY

H = average transportation cost per site of a maintenance trip (or "tour") from the CMF to a site

MCF_i = mission-critical flag for LRU type i, equals 1 if the LRU type is deemed mission-critical but is not backed up at the sites by inventory or by redundancy, equals 0 otherwise (further definition appears below)

DS = fraction of radar system incidents (demands for maintenance action) detected automatically, including those met by repair in place, and those which do not cause system to become inoperative (e.g., failure of a redundant LRU)

SMTBI = overall mean time between incidents (maintenance actions) for one radar, in hours; must satisfy

$$\frac{1}{SMTBI} > \sum_{i=1}^{N} \frac{QPA_i}{MTBI_i}$$

to reflect the fact that a radar is more than the serial array of its component LRUs

CPMI = shortest preventive maintenance interval for CMF personnel trips to a radar site (in hours)

CPMP = average number of CMF personnel required on a scheduled preventive maintenance trip to a radar site

ADPM = average number of days required to complete a preventive maintenance trip to a site, from the time of leaving the CMF until return to the CMF. (If preventive maintenance is accomplished via "tours" of the M sites, then the tour time is averaged over the M sites.)

The following definitions are included here for completeness:

RL_i = repair level for LRU type i, equals 0 if LRU is to be condemned on failure, at the site, equals 1 if LRU repair is to be attempted (i.e., lowest level repair) at site, equals 2 if LRU repair is to be attempted (i.e., lowest level repair) at CMF, equals 3 if LRU is to be repaired only at depot level

$CCOND_i$ = fraction of failed (and removed) LRUs which are condemned at the CMF, due to wear-out.

In the derivation of the formula for C_2, it is assumed that the CMF has the capability to identify all false pulls, even if the particular LRU is designated for depot repair. Thus, all failed and falsely pulled LRUs which cannot be repaired at the site are sent to the CMF for a bench check ($CBCMH_i$ time) which will identify failed LRUs.

2.2.1 Repair Level Data Inputs

The fractions $COND_i$, $SRTS_i$, $CRTS_i$, $CCOND_i$, $DCOND_i$, and $DRTS_i$ represent the fractional corrective maintenance allocation of all failed and removed (i.e., failures not repaired in place - RIP) LRUs of type i. Accordingly, these fractions satisfy the identity

$$COND_i + SRTS_i + CRTS_i + CCOND_i + DRTS_i + DCOND_i = 1.$$

Depending on the repair levels input by the model user, several of these fractions may be zero. For each LRU type, one of the following four repair levels must be input: condemn on failure at site, lowest repair at site, lowest repair at CMF, or lowest repair at the depot. Thus, for each LRU type i, given its repair level, RL_i, the LCC Model will supply values for the six fractions above. The table below illustrates this process. Given the repair level RL_i of a particular LRU type i, the model user must provide the non-zero fractional values required to fill in the appropriate column in the table. This must be done so that the column total equals one. Note that the value of $COND_i$ reflects a repair level decision, whereas $CCOND_i$ or $DCOND_i$ reflects the wear-out rate ($WOR1_i$ if $RL_i = 1$, $WOR2_i$ if $RL_i = 2$, $WOR3_i$ if $RL_i = 3$) of a normally repairable LRU.

CONTRACTOR INPUT: $RL_i = \begin{cases} 0 \text{ Condemn on Failure, At Site} \\ 1 \text{ Lowest Repair at Site} \\ 2 \text{ Lowest Repair at CMF} \\ 3 \text{ Lowest Repair at Depot} \end{cases}$

	IF $RL_i = 0$ CONDEMN AT SITE	IF $RL_i = 1$ LOWEST REPAIR AT SITE	IF $RL_i = 2$ LOWEST REPAIR AT CMF	IF $RL_i = 3$ LOWEST REPAIR AT DEPOT
$COND_i$ = fraction of failures condemned at the site	1	0	0	0
$SRTS_i$ = fraction of failures repaired at the site	0	$SRTS1_i$	0	0
$CRTS_i$ = fraction of failures repaired at the CMF	0	$CRTS1_i$	$CRTS2_i$	0
$CCOND_i$ = fraction of failures condemned at the CMF	0	$WOR1_i$	$WOR2_i$	0
$DCOND_i$ = fraction of failures condemned at depot	0	0	0	$WOR3_i$
$DRTS_i$ = fraction of failures repaired at depot	0	$DRTS1_i$	$DRTS2_i$	$DRTS3_i$

2.2.2 Mission Criticality Data Inputs

In one component of the formula for C_2, the mission-critical flag MCF_i appears. This flag is computed internally by the LCC Model:

$$MCF_i = \begin{cases} 1 \text{ if } MCI_i = 1 \text{ and } STK_i + QR_i = 0 \\ 0 \text{ otherwise} \end{cases}$$

where MCI_i is a "mission critical indicator" which must be input to the model,

$$MCI_i = \begin{cases} 0 \text{ if LRU type i is not mission-critical} \\ 1 \text{ if LRU type i is mission-critical, with no special site stocking provision made for it} \\ 2 \text{ if LRU type i is mission-critical and must have initial site inventory } \geq 1 \end{cases}$$

and STK_i is the number of investment spares (initial inventory) of LRU type i per site, QR_i is the number of LRUs of type i which are redundant (i.e., a minimum of $QPA_i - QR_i$ are sufficient to maintain operational status of the system). QR_i must be input to the model, and STK_i is computed internally (see discussion of Cost Element for Investment Spares).

2.2.3 Maintenance Personnel Constraints

In addition to calculation of life cycle costs, the SEEK IGLOO LCC Model computes manhours expended in maintenance at the site, CMF, and depot levels and performs an internal verification of whether proposed designs meet five particular manhour constraints. The first is that the total manhours expended by site radar maintenance personnel in performing preventive maintenance and in removing and replacing failed LRUs is subject to a specification limit equal to MXHRS manhours per site per year.* The second constraint is that the number of radar maintenance personnel assigned to a site must be sufficient to cover the total maintenance manhours expended there. The third constraint is that the number NSP of dedicated radar maintenance personnel at each site meet the specified limitation $NSP \leq 3$.**

The fourth and fifth constraints are that the numbers of maintenance personnel assigned to the CMF and to the depot to support the SEEK IGLOO system (independent inputs to the model) must be sufficient to cover the total maintenance manhours expended at the CMF and depot, respectively.

The maintenance manhours which are subject to the first constraint (denoted as SMMH) are computed by the formula below. The first term in this formula accounts for manhours expended in place for preparation and access to failed (and falsely pulled) LRUs, for in-place repair manhours, and for manhours spent in removing LRUs. The second term accounts for manhours expended by site maintenance personnel in scheduled preventive maintenance tasks.

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* The value of MXHRS must be input as 1300 manhours per site per year as per the SEEK IGLOO System Specification, Paragraph 3.5.1.4.

** As per the SEEK IGLOO System Specification, Paragraph 3.5.1.1.

$$SMMH = \sum_{i=1}^{N} \frac{YOH \cdot K \cdot (QPA_i)}{MTBI_i} \Big| (1+FPR_i)(PAMH_i) + (RIP_i)(IMH_i)$$

$$+ (1-RIP_i)(1+FPR_i)(RMH_i) \Big|$$

$$+ \sum_{j=1}^{FA} \frac{YOH}{(SMI_j)} \cdot (MMH_j)$$

where

$PAMH_i$ = average manhours expended in place for preparation and access to an LRU of type i

IMH_i = average manhours to perform in-place repair of the LRU, including fault isolation, repair and verification

RMH_i = average manhours to fault isolate, remove and replace a faulty (or falsely pulled) LRU and verify restoration of the system to operational status.

Thus, Contractor designs must satisfy the SEEK IGLOO system specification that $SMMH \leq MXHRS$ (i.e., $SMMH \leq 1300$).

Notes: (i) The MXHRS constraint is independent of the number of maintenance personnel designated per site, NSP. (ii) Off-equipment site maintenance manhours, and maintenance performed by CMF personnel at the radar sites, are excluded from the MXHRS constraint.

Off-equipment site maintenance manhours are computed using the formula:

$$SPMH = \sum_{i=1}^{N} \frac{YOH \cdot K \cdot (QPA_i)(1-RIP_i)}{MTBI_i} \Big| (1+FPR_i)(BCMH_i) + (SRTS_i)(SMH_i) \Big|$$

Thus, if

SAA = available work time per site radar maintenance man in hours per year

then the second manhour constraint is expressed by the inequality

$$SMMH + SPMH \leq (NSP)(SAA).$$

Also, in the above equations, we define

$BCMH_i$ = average manhours at the site to perform a shop bench check, screening and fault verification of the removed LRU prior to initiating repair action or condemning the item

SMH_i = average manhours to perform site-level corrective maintenance of a removed LRU including fault isolation, repair and verification

FA = number of different functional areas in the radar system

SMI_j = average scheduled maintenance interval (in hours) for preventive maintenance of functional area j by site maintenance personnel

MMH_j = average manhours required to perform a scheduled maintenance task for site personnel in functional area j.

The fourth and fifth constraints concern the model inputs NCP and NDP, respectively, where

NCP = number of CMF maintenance personnel

NDP = number of depot personnel required for maintenance of the SEEK IGLOO system.

The yearly maintenance hours expended by CMF personnel is computed via the formula below, where the first term accounts for corrective maintenance time spent on removed LRUs which is performed at the CMF, the second term accounts for time spent by CMF personnel on emergency corrective maintenance trips to the sites, and the third term accounts for time spent by CMF personnel on preventive maintenance trips to the sites.

$$CLH = M \cdot \sum_{i=1}^{N} \frac{(YOH)\ K\ (QPA_i)(1-RIP_i)}{MTBI_i} \ X$$

$$\left[(1+FPR_i)(SNRTS_i)(CBCMH_i) + (CRTS_i)(CMH_i) + (FPR_i)(COND_i)(CBCMH_i)\right]$$

$$+ M(YOH)(CCMP)(ADCM)(CDWH) \cdot K \cdot \left| \sum_{i=1}^{N} \frac{(MCF_i)(QPA_i)(1-RIP_i)}{MTBI_i} + \frac{(1-DS)}{SMTBI} \right|$$

$$+ \frac{M(YOH)}{CPMI}(CPMP)(ADPM)(CDWH)$$

where

CDWH = working hours per day credited to each of the CMF personnel on a maintenance trip to a site.

The yearly corrective maintenance hours expended by depot personnel is given by

$$DLH = M \cdot \sum_{i=1}^{N} \frac{(YOH)\ K\ (QPA_i)(1-RIP_i)}{MTBI_i} \left[(DCOND_i + DRTS_i)(DBCMH_i)\right.$$

$$\left. + (DRTS_i)(DMH_i)\right].$$

The number of maintenance personnel at the CMF is then required to satisfy

$$CLH \leq (NCP)(CAA)$$

where

CAA = available working time per CMF maintenance man in hours per year.

Similarly, the number of maintenance personnel at the depot is required to satisfy

$$DLH \leq (NDP)(DAA)$$

where

DAA = available working time per depot maintenance man in hours per year.

2.3 Investment Spares

The SEEK IGLOO LCC Model internally computes stocking levels based upon standard Air Force stockout criteria. The criteria used for depot and CMF stocking levels are consistent with a standard Air Force stock control procedure* and have been shown numerically to be equivalent to the "expected number of backorders" criterion of the LSC Model.**

As explained below, the "expected number of backorders" criterion is not appropriate for setting stockout levels at the radar sites. Thus, a "confidence factor" criterion is employed for such inventories. A special provision is included to offer a tradeoff capability on whether mission-critical LRUs be stocked no less than one per site regardless of cost.

The cost of investment spares, denoted C_3, will be calculated by the formula:

$$C_3 = M \cdot \sum_{i=1}^{N} (STK_i)(UC_i)(XUC) + \sum_{i=1}^{N} F(CAS_i)(UC_i)(XUC) + \sum_{i=1}^{N} F(DAS_i)(UC_i)(XUC)$$

where

STK_i = number of investment spares per site of LRU type i

UC_i = unit cost to Government of LRU type i, final production item on cumulative average learning curve, as used to calculate the value of PME in Cost Element for Development & Production. (Note: Unit production cost, G&A, and profit are to be included.)

* Stock Control at Bases, Chapter 11 of Air Force Manual AFM 67-1, Vol. II, Part One, 4 March 1974.

** Logistics Support Cost Model, User's Handbook, Headquarters AFLC/AQMLE, June 1975

XUC = dummy variable (see discussion under Development and Production cost element)

CAS_i = average number of LRUs of type i in the central maintenance facility (CMF) pipeline

DAS_i = average number of LRUs of type i in the depot pipeline

The function F is defined below.

The first term in C_3 is the total cost of the initial stock of spares at the M radar sites, the second term is the cost of initial spares at the CMF, and the third term is the cost of initial stock at the depot.

In C_3, the value of STK_i is computed to be smallest non-negative integer which satisfies both

$$\sum_{m=0}^{STK_i + QR_i} \frac{(SAS_i)^m e^{-(SAS_i)}}{m!} \geq CONF \qquad (2.1)$$

and

$$STK_i \geq MCI_i - 1, \qquad (2.2)$$

where SAS_i is the average number of failed and falsely pulled LRUs which have accumulated by the end of an order and shipping interval (SOSI, see below). This term is calculated via the following formula:

$$SAS_i = \frac{(QPA_i)K(WOH)(1-RIP_i)(1 + FPR_i)}{MTBI_i} \left[(SRTS_i)(SRCT) + (1-SRTS_i)(SOSI) \right]$$

In the above formula, we define

WOH = weekly operating hours (= YOH/52.18 where YOH = yearly operating hours)

SRCT = average site repair cycle time in weeks (the elapsed time from removal of a failed LRU until it is placed in site serviceable stock)

CONF = confidence factor (the probability that the stock of a given LRU will last from one resupply trip to the next)

QR_i = number of LRUs of type i which are redundant, i.e., a minimum of $(QPA_i - QR_i)$ are sufficient to maintain operational status of the system

MCI_i = "Mission critical indicator", equals 0 if LRU type i is not mission critical, equals 1 if LRU type i is mission critical with zero initial site inventory allowable, equals 2 if LRU type i is mission critical and must have non-zero initial site inventory

SOSI = order and shipping interval between each site and the CMF, in weeks (i.e., number of weeks between resupply trips).

In calculating SAS_i, we are assuming that the SRCT for a falsely pulled LRU is not significantly different from that of a failed LRU. In addition, if a failure can only be isolated to a group of, say, three LRUs, then we assume that either the failure can be repaired at the site or all three LRUs must be shipped to the CMF for fault isolation and repair.

In addition, in calculating STK_i, we are assuming the following:

1. There are regular resupply runs from the CMF to each site which are SOSI apart in time.
2. Stocking levels at each site are full (up to STK_i level) at the beginning of each SOSI (i.e., immediately after a resupply run).

3. Redundant LRUs are treated as "spares" in the sense that the system is operational when at least (QPA_i - QR_i) LRUs of each type i are functioning.

4. Formula (2.1) assumes a Poisson incident rate (i.e., exponential MTBI) with a full complement (= QPA_i) of each LRU type i in operation at all times. In fact, fewer than QPA_i LRUs of type i (down to QPA_i - QR_i) may be in operation at any given time. Hence, the combined incident rate for a given LRU may occasionally be less than that which we assume. In this sense, formula (2.1) yields a conservative value for STK_i when $QR_i > 0$.

5. If there is no spare at a site to replace a "mission critical" LRU which has failed, then the system becomes inoperative (and hence, no further failures will occur). Thus, the maximum possible backorder for that LRU will be 1. For this reason, the expected backorder criterion for sparing used in the LSC model is not appropriate for site sparing in SEEK IGLOO.

Based on the above assumptions, each STK_i value is computed so as to guarantee that the probability that the stock <u>of LRU type i</u> will last <u>any given</u> SOSI is at least CONF (with the added requirement that for any mission critical LRU type i with MCI_i = 2, STK_i must be at least 1). Note that this is not the same as the probability that the stocking levels of <u>all</u> LRUs will last any given SOSI.

The term CAS_i is computed by using the following formula:

$$CAS_i = \frac{M(WOH)K(QPA_i)(1-RIP_i)}{MTBI_i} \times$$

$$\Big| (FPR_i)(1-SRTS_i)(CRCT) + (CRTS_i)(CRCT)$$

$$+ (CCOND_i + DRTS_i + DCOND_i)(OST + SOSI/2)$$

$$+ (COND_i)(OST) \Big|$$

where

CRCT = CMF repair cycle time (in weeks) for an LRU, from removal at the site of the failed (or falsely pulled) item until it is returned to CMF serviceable stock

OST = average order and shipping time (in weeks) from the depot to the CMF.

The terms in the above equation account, respectively, for false pulls sent to the CMF, LRUs repaired at the CMF, failed LRUs which are sent to the CMF but not repaired there, and throwaway ($COND_i = 1$) LRU failures.

The term DAS_i is computed via:

$$DAS_i = \frac{M \cdot K(QPA_i)(WOH)(1-RIP_i)}{MTBI_i} (DRTS_i)(DRCT)$$

where

DRCT = depot repair cycle time, i.e., the time from when the CMF sends a repairable LRU to the depot until it is repaired and placed in depot serviceable stock (in weeks).

Note: Condemned LRUs in the depot pipeline are not included in the Cost Element for Investment Spares, because it is assumed that all safety spares for condemned items will be used up by the end of the life cycle.

In the formula for C_3, the function F(X), where X is CAS_i or DAS_i, is defined as

$$F(X) = \left| X + B \sqrt{X} + .5 \right|$$

where the bars represent truncating of any fractional portion. For the case of an assumed Poisson distribution of LRU demands with mean demand rate X, F(X) calculates the required sparing level, with safety stock, which is equal to that obtained by using the expected backorder (EBO) criterion of the LSC Model. For example, if B=1.65 then sparing at the F(X) level guarantees that $EBO \leq 0.1$. The EBO criterion for CMF and depot sparing is appropriate because a backorder at the CMF or depot does not necessarily affect the LRU demand rate.

2.4 Replenishment Spares

This cost element is primarily comprised of the cost of replacing LRUs which are condemned throughout the life cycle, either by the repair level designation of "discard on failure" (RL=0) or due to normal wearout. Also included is the cost of repair material at indenture levels lower than the LRU which are consumed in the repair of LRUs.

The cost C_4 of replenishment spares for the lifetime of the system is computed as

$$C_4 = M \cdot \sum_{i=1}^{N} \frac{(PIUP)(YOH)\ K\ (QPA_i)(1-RIP_i)}{MTBI_i} \times [WR_i + (1-WR_i)RM_i](UC_i)(XUC)$$

where

$$WR_i = COND_i + CCOND_i + DCOND_i$$

= fraction of failed LRUs which are condemned

and

RM_i = repair materials factor for LRU type i, the fraction of UC_i that is consumed (in lower indenture level components of the LRU) in the repair of LRU type i.

2.5 Consumables

Consumables to be considered are primary power (for prime mission equipment) and secondary power (for heating or air conditioning necessary for prime mission equipment).

The cost C_5 for consumables is given by

$$C_5 = M \cdot PIUP \cdot \left[(PPRS + SPRS) \cdot YOH \cdot FCS + MCRS \right]$$

where

PPRS = consumption rate for primary power (for prime mission equipment) per radar site, in kilowatts

SPRS = consumption rate for secondary power (heating and air conditioning necessary for PME) per radar site, in kilowatts

FCS = fuel cost at radar sites, in $/kilowatt hour per site

MCRS = miscellaneous consumption rate per radar site, to include all other consumables in $/year; lamps, fuses, and other items which are of lower indenture level than LRU and not included in any RM_i must be included here.

2.6 Support Equipment

To offer the greatest versatility to Contractors when using the SEEK IGLOO LCC Model for tradeoff studies, the concept of LRU repair at sites will be allowed.* However, all such repair must be within the skill level of site personnel as provided under the Cost Element for Maintenance (Labor). Thus, the model is designed to accept support equipment at each of the 13 sites, at Elmendorf AFB, and at Sacramento ALC. The recurring component of support equipment cost is based upon annual costs to operate and maintain each piece of support equipment throughout the operational service life of the system.

The cost C_6 of support equipment (SE) is thus given by:

$$C_6 = M \cdot \sum_{\ell=1}^{A} (NSES_\ell)[1+(PIUP)(COS_\ell)](SEC_\ell)$$

$$+ \sum_{\ell=1}^{A} (NSEC_\ell)[1+(PIUP)(COC_\ell)](SEC_\ell)$$

$$+ \sum_{\ell=1}^{A} (NSED_\ell)[1+(PIUP)(COD_\ell)](SEC_\ell)$$

*See footnote on page 14.

where

A = number of different types of SE (whether common or peculiar) at all levels

$NSES_\ell$ = number of pieces of SE of type ℓ required at each site (whether common or peculiar)

SEC_ℓ = unit cost of SE of type ℓ

$NSEC_\ell$ = number of pieces of SE of type ℓ required at the CMF (whether common or peculiar)

$NSED_\ell$ = number of pieces of peculiar SE of type ℓ required at the depot

COS_ℓ = annual cost to operate and maintain one piece of SE of type ℓ at a site, expressed as a fraction of the unit cost (SEC_ℓ); not applicable if $NSES_\ell$=0

COC_ℓ = same as COS_ℓ, except refers to the CMF; not applicable if $NSEC_\ell$=0

COD_ℓ = same as COS_ℓ, except refers to the depot; not applicable if $NSED_\ell$=0

2.7 Facilities

Since the SEEK IGLOO Minimally Attended Radars will be installed at existing radar sites, there will be both existing facilities and new facilities. Only the costs of new facilities are to be included. The cost C_7 of additional facilities required for installation of the new radar system is thus computed as

$$C_7 = M \cdot \sum_{\ell=1}^{L} (FAC_\ell)$$

where

L = number of new facilities required at each site

and

FAC_ℓ = cost of facility ℓ.

Note: If any component of the SEEK IGLOO radar system requires maintenance and/or inventory, it should be designated as an "LRU" and not a "facility"; its acquisition cost will appear in the Cost Element for Development & Production, not in the Cost Element for Facilities.

Note: It is intended that heating and air conditioning units required for MAR operation be considered as LRUs. Components of the SEEK IGLOO system considered as LRUs will appear in the Cost Element for Development & Production and not in the Cost Element for Facilities.

2.8 Training

Initial training costs for SEEK IGLOO are computed according to the following concept: The contractor will train a cadre of personnel from the AAC radar squadron stationed at Elmendorf AFB. This cadre will perform subsequent training of the service personnel for the contractor who wins the service contract for site and CMF maintenance. This cadre will also perform the depot level training. Initial training is considered to be completed in the first year of SEEK IGLOO system operation.

Recurring training costs are based on turnover rates of site, CMF, and depot personnel, after the first year of SEEK IGLOO system operation. The full-time costs of the AAC training cadre are included in the cost of training. In this manner, the recurring training costs for new cadre personnel are absorbed in their yearly salaries over the lifetime of the system.

The cost for maintenance personnel training is given by:

$$C_8 = (CADRE)[(TWCAD)(TCCAD) + (YSCAD)(PIUP)] + [M(NSP) + NCP + NDP][1 + (PIUP-1)(TR)](TW)(TC) + TE$$

where

CADRE = number of personnel from the AAC radar squadron who are designated to perform maintenance training over the lifetime of the system (10)

TWCAD = number of weeks required for the initial training of "CADRE" personnel

TCCAD = cost per student per week for "CADRE" training

YSCAD = yearly salary for "CADRE" personnel

NSP = number of radar maintenance personnel per radar site

NCP = number of CMF maintenance personnel

NDP = number of depot personnel required for maintenance of the SEEK IGLOO system

TR = average turnover rate for site, CMF, and depot maintenance personnel

TW = average number of weeks training required for site, CMF, and depot maintenance personnel

TC = average cost per student per week for site, CMF, and depot maintenance training (not including student salaries)

TE = cost of peculiar training equipment required by the Government; not to include any Contractor-incurred costs already accounted for in the Cost Element for Development and Production.

Thus, the terms in C_8 account for the initial and recurring training costs for "CADRE" personnel, site, CMF, and depot maintenance personnel, and training equipment, respectively.

2.8.1 Advisory Information for Preparing Inputs

The number NSP input to the model must satisfy two constraints. First, the total manhours expended by site radar maintenance personnel in performing preventive maintenance and in removing and replacing failed LRUs is subject to a specification limit input as MXHRS manhours per site per year. The second limitation is that the number of radar maintenance personnel assigned to a site must be sufficient to cover the total maintenance manhours expended there. (The model performs an internal verification of these constraints.)

The numbers NCP and NDP input to the LCC Model must satisfy the constraints that the numbers of maintenance personnel assigned to the CMF and depot must be sufficient to cover the total maintenance manhours expended there. (The model performs an internal verification of these constraints.) When inputting values of NCP and NDP, the user should also take into consideration the fact that the SEEK IGLOO LCC Model does not quantitatively express the actual skill mix among CMF or depot maintenance personnel.

The inputs TR, TW, and TC are averages of values which are typically different for site, CMF, and depot personnel. (E.g., TR is actually an average of turnover rates for site, CMF, and depot maintenance personnel. These three values are typically obtained from separate data sources.)

The value of TC should be equal to the cost per student per week to offer a training course, not including the costs for paying the students their weekly salaries to attend. The same statement applies to the value of TCCAD.

2.9 Inventory Management

The cost C_9 of inventory management is given by the formula:

$$C_9 = [IMC + (PIUP)(RMC)] \cdot \sum_{i=1}^{N} [1 + U(1-COND_i) \cdot PA_i]$$

$$+ M \cdot SA \cdot (PIUP) \cdot \sum_{i=1}^{N} [1 + U(SRTS_i) \cdot PA_i]$$

$$+ SA \cdot (PIUP) \cdot \sum_{i=1}^{N} [1 + U(CRTS_i) \cdot PA_i]$$

where

IMC = initial management cost to introduce a new line item of supply into the Air Force inventory

RMC = recurring annual cost to maintain an item of supply in the depot inventory system

PA_i = number of new "P" coded (i.e., procurable) repairable assemblies, sub-assemblies, and piece parts which will be stocked to support repair of LRU type i

SA = annual cost to maintain a line item in the site or CMF inventory system

and

U(X) is the unit step function

$$U(X) = \begin{cases} 0 & \text{if } X \leq 0 \\ 1 & \text{if } X > 0 \end{cases}$$

The terms in C_9 account for the inventory management costs at the depot, the M sites, and the CMF, respectively.

Note: Lower assemblies, sub-assemblies, and piece parts within an LRU are considered to be stocked at a site, the CMF, or the depot only if they are to be repaired there. Since the cost of inventory management is based upon the number of different inventories among the sites, CMF, and depot, the LCC Model inputs PA_i need count only once any assembly, sub-assembly, or piece part which exists on several LRU types i which have identical values of $U(1\text{-}COND_i)$. Similar statements hold for inventories shared by LRUs with identical values of $U(SRTS_i)$, and again for inventories shared by LRUs with identical values of $U(CRTS_i)$. Note that the function U serves to identify those locations where an inventory of replacement parts is necessary for any LRU type (depending upon repair strategy).

2.10 Software Maintenance

Software maintenance *per se* will be performed only at depot level (Sacramento ALC). However, the SEEK IGLOO radar can be expected to employ firmware (PROMs, EROMs). Thus, although the program logic will be maintained solely at Sacramento ALC, the physical reprogramming (i.e., erasing and re-writing) efforts could be performed at both Elmendorf AFB and Sacramento ALC.

Tradeoff studies which allow for the cost of software/firmware maintenance must also allow for the hardware equivalent: hardware ECP enhancement (or growth) costs. All contractors using the LCC Model will be required to use equivalent Air Force-provided software/firmware/hardware growth patterns.

The cost C_{10} of software maintenance is calculated as follows:

$$C_{10} = SWFAC + PIUP \cdot \sum_{j=1}^{FA} ENYR_j \; (HWCOST_j + SWCOST_j)$$

where

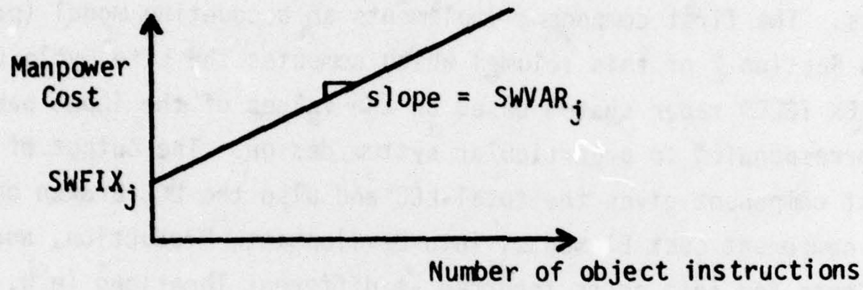
$$HWCOST_j = (WEIGHT_j)(HWCF_j)(CPWT)$$

$$SWCOST_j = SWFIX_j + (SWVAR_j)(SIZE_j)(SWCF_j)$$

The variables PIUP and FA are found in previous cost elements. The remainder are defined below:

- SWFAC = one-time cost of a software maintenance facility, if one is intended to be used, exclusive of fixed and variable costs $SWFIX_j$ and $SWVAR_j$ included in the calculations of $SWCOST_j$
- $ENYR_j$ = expected number of enhancements (including fixups) per year which will occur in functional area j throughout the life of the system
- $HWCOST_j$ = hardware component of enhancement (and fixup) cost for functional area j
- $SWCOST_j$ = software component of enhancement (and fixup) cost for functional area j
- $WEIGHT_j$ = weight of all hardware and firmware in functional area j, in pounds
- $HWCF_j$ = hardware change fraction for functional area j, the expected fraction of the hardware or firmware component of functional area j which is to be changed per enhancement (or fixup) required in that functional area
- CPWT = manpower cost per unit weight (pound) affected by enhancement (or fixup), based upon an aggregate to include both hardware ECPs and the physical aspects of the reprogramming of firmware
- $SIZE_j$ = size of software component of functional area j, including all programs residing in firmware, in number of object instructions (or the equivalent, for higher order languages)
- $SWCF_j$ = software change fraction for functional area j, the expected fraction of the software component of functional area j (including programs residing in firmware) which is to be changed per enhancement (or fixup) required in that functional area.

The inputs $SWFIX_j$ and $SWVAR_j$ are respectively the fixed component and the coefficient of the variable component of manpower cost when described as a function of the number of object instructions programmed (or reprogrammed) in functional area j. See the figure below.



<u>Note</u>: Contractors must clearly indicate components of costs attributed to SWFAC and to SWFIX when submitting results of computations using the SEEK IGLOO LCC Model.

SECTION 3

FEATURES OF THE COMPUTER MODEL

3.1 Sensitivity Analysis

The SEEK IGLOO LCC Model computer program consists of two main components. The first component implements an accounting model (presented in Section 2 of this volume) which computes the Life Cycle Cost of the SEEK IGLOO radar system based on the values of the input parameters corresponding to a particular system design. The output of this first component gives the total LCC and also the LCC broken out into ten component Cost Elements, into Development, Production, and Support Costs and into costs incurred at different locations (e.g., radar sites versus repair facilities). The breakdown of Life Cycle Cost into various categories should help the user identify areas in which design and cost trade-offs should be considered.

The second component of the LCC computer program provides Sensitivity Analysis computations to be used as an additional aid in trade-off considerations. More specifically, for certain selected contractor parameter inputs, this program component computes the average change (either positive or negative) in total LCC which is produced by a fractional increase in the value of the given parameter.

In particular, one section of the Sensitivity Analysis calculations will help the user assess the trade-off value of making repairs of failed assemblies at differing locations (i.e., repair on site versus repair at a central maintenance facility or CMF (Elmendorf AFB) versus repair at the depot (Sacramento ALC)). Thus, these calculations should further aid the user in identifying elements of his radar system design to which the LCC is particularly sensitive, again indicating possible trade-offs in design and/or maintenance concepts. (For a full discussion of the Sensitivity Analysis component, see the SEEK IGLOO LCC Model User's Manual,* Appendix D.)

3.2 Interactive Use of the Model

The SEEK IGLOO LCC Model is designed for interactive use via a time-shared capability. However, the LCC Model may easily be converted to batch mode (see the User's Manual,** Appendix E, for instructions).

A brief description of the organization of the full SEEK IGLOO LCC Model, in its interactive mode, is as follows: First, the nominal values of five standard input data files (which include Government and Contractor data) are read into the model. Next, certain control parameters (e.g., instructions for output format) are input by the user from his terminal. At this point, the user may also over-write the nominal values of any selection of previous data inputs. Control is then transferred to the computer processor where the program calculates successively the Life Cycle Cost of the modeled radar system and the related values of the Sensitivity Analysis. The output of these computations is then directed to two separate devices. If the appropriate control parameter indicates that an off-line copy of output data is required, then the complete set of program output is produced on the off-line printer, including the LCC broken out into various categories and the Sensitivity Analysis values of all designated input factors. In addition, the user's terminal may receive a subset of the LCC output and the values of the Sensitivity Analysis calculations for a selected number of "most sensitive" input factors.

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*ESD-TR-78-155, Vol. II, SEEK IGLOO Life Cycle Cost Model, User's Manual.

**ibid.

The user is then asked at the terminal if he wishes another run. A "NO" response terminates the program. A "YES" response transfers the user back to the second step in the system operation where he may input new values for the control parameters and/or over-write the nominal values of a different selection of previous data inputs and then make a new run of the LCC Model. The user can make as many successive modifications of his data and reruns of the LCC Model in this interactive mode as he wishes. Alternatively, if the user wishes to perform a detailed analysis of the LCC output and Sensitivity Analysis factors before he reruns the model, he can terminate the program and use the off-line output as an aid in re-evaluating his radar system design and maintenance concepts. (See the User's Manual,* Section 3.3, for a full discussion of the LCC Model interactive capability.)

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*ibid.

APPENDIX

SOURCES FOR INPUT DATA

All FORTRAN variables which are evaluated directly from input data (i.e., variables not internally computed by the SEEK IGLOO LCC Model) are listed in this Appendix. Distinction is made between variables evaluated via Contractor-provided and Government-provided input data; for the latter set, numerical values are given.

The formal definition for each input variable may be located in this volume via reference to the section number in which that variable first appears.

The variables A, L, and N, which represent the numbers of different types of support equipment, new facilities per site, and different LRU types, respectively, are not considered input data but are each evaluated by the LCC Model via a count of the number of items submitted in the appropriate data file.

Contractor Data Inputs

FORTRAN Variable	First Appears in Section	FORTRAN Variable	First Appears in Section
$BCMH_i$	2.2.3	FPR_i	2.2
$CBCMH_i$	2.2	FSD	2.1
CCMP	2.2	$HWCF_j$	2.10
CMH_i	2.2	IMH_i	2.2.3
COC_ℓ	2.6	MCI_i	2.2.2
COD_ℓ	2.6	MCRS	2.5
COS_ℓ	2.6	MMH_j	2.2.3
CPMI	2.2	$MTBI_i$	2.2
CPMP	2.2	NCP	2.2.3
CPWT	2.10	NDP	2.2.3
$CRTS1_i$	2.2.1	$NSEC_\ell$	2.6
$CRTS2_i$	2.2.1	$NSED_\ell$	2.6
$DBCMH_i$	2.2	$NSES_\ell$	2.6
DMH_i	2.2	NSP	2.2
$DRTS1_i$	2.2.1	PA_i	2.9
$DRTS2_i$	2.2.1	$PAMH_i$	2.2.3
$DRTS3_i$	2.2.1	PME	2.1
DS	2.2	PPRS	2.5
FA	2.2.3	PRODX	2.1
FAC_ℓ	2.7	QPA_i	2.2

Contractor Data Inputs (Cont'd)

FORTRAN Variable	First Appears in Section	FORTRAN Variable	First Appears in Section
QR_i	2.3	SWFAC	2.10
REFURB	2.1	$SWFIX_j$	2.10
RIP_i	2.2	$SWVAR_j$	2.10
RL_i	2.2	TC	2.8
RM_i	2.4	TCCAD	2.8
RMH_i	2.2.3	TE	2.8
SEC_ℓ	2.6	TW	2.8
$SIZE_j$	2.10	TWCAD	2.8
SMH_i	2.2.3	UC_i	2.3
SMI_j	2.2.3	VAL	2.1
SMTBI	2.2	$WEIGHT_j$	2.10
SPRS	2.5	$WOR1_i$	2.2.1
$SRTS1_i$	2.2.1	$WOR2_i$	2.2.1
SW	2.1	$WOR3_i$	2.2.1
$SWCF_j$	2.10		

Government Data Inputs

FORTRAN Variable	First Appears in Section	Numerical Value
ADCM	2.2	3 days
ADPM	2.2	2 days
B	2.3	1.65
CAA	2.2.3	1512 hours/year
CADRE	2.8	10
CDR	2.2	$160./day
CDWH	2.2.3	8 hours
CLR	2.2	$13.97/hour
CONF	2.3	.98
CRCT	2.3	1.43 weeks
DAA	2.2.3	1512 hours/year
DLR	2.2	$15.52/hr
DRCT	2.3	6 weeks
$ENYR_j$	2.10	1 per FA per year
FCS	2.5	$0.0518/kw hr/site
H	2.2	$1600 per trip
IMC	2.9	$40.91/item
K	2.2	3
M	2.2	13 sites
MXHRS	2.2.3	1300 man hours/site/yr
OST	2.3	1.56 weeks
PIUP	2.2	20 years
RMC	2.9	$104.20/item/year
SA	2.9	$20.20/item/year
SAA	2.2.3	1512 hours/year
SOSI	2.3	1 week

Government Data Inputs (Cont'd)

FORTRAN Variable	First Appears in Section	Numerical Value
SRCT	2.3	.43 week
TR	2.8	1.0
XUC	2.1	1.0
YOH	2.2	8766 hours/year
YSCAD	2.8	$13400/man/year
YSLR	2.2	$52000/man/year