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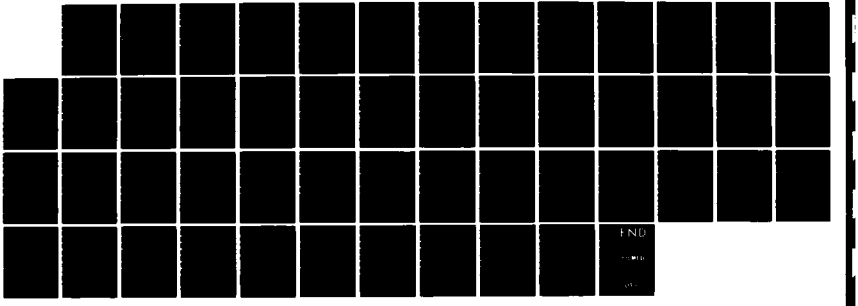

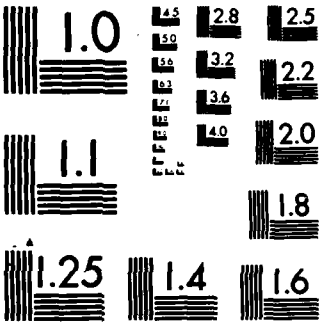

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VALIDATION OF THE ALGORITHMS FOR BASE EXCHANGEABLE REPAIR COSTS (NSN) AND BASE EXCHANGEABLE MODIFICATION COSTS (NSN) FOR THE COMPONENT SUPPORT COST SYSTEM (CSCS) (D160B)

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Submitted to:

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EXECUTIVE SUMMARY

Visibility and Management of Operating and Support Costs is a program initiated by the Office of the Secretary of Defense (OSD) in order to ensure that each Military Department gathers, tracks, and computes operating and support costs by weapon system. VAMOSC II is an Air Force management information system which is responsive to the OSD initiative. It uses information from existing Air Force systems to satisfy both Air Force and OSD needs for certain weapon system operating and support (O&S) costs.

At present, the VAMOSC II system comprises three subsystems:

(1) The Weapon System Support Cost (WSSC) system (D160), which deals with aircraft,

(2) The Communications - Electronics (C-E) system (D160A), which deals with ground communications - electronics equipment,

(3) The Component Support Cost Subsystem (CSCS) (D160B), which deals with subsystems and components for aircraft.

The Component Support Cost System (CSCS) of VAMOSC II gathers and computes support costs by assembly/subassembly and relates those costs back to the end item or weapon system. CSCS

replaces the Logistic Support Cost (LSC) model of K051 (AFLCR 400-49) for aircraft and engines.

The CSCS receives inputs from 14 Air Force data systems. On a quarterly basis, the system provides two standard reports each processing cycle and twelve other types of reports as requested by users. It also provides pre-programmed data base extracts on magnetic tape on a one-time basis in response to user requests. Special requests for data in user selected format may also be satisfied on a case by case basis.

At the heart of the CSCS is a set of 30 algorithms for estimation or allocation of costs. Information Spectrum, Inc. (ISI) was awarded a contract to validate these algorithms. This effort included investigations of logic, appropriateness of the algorithms and assumptions inherent in the algorithms. ISI was also to survey published findings, reports of audit, etc. relating to the accuracy to the source data systems. In addition to the algorithm validation, ISI was to perform certain "special tasks," including a user survey.

This report provides in one cover the validation of two algorithms, called "Base Exchangeable Repair Costs (NSN)" and "Base Exchangeable Modification Costs (NSN)." The two are combined because of the similarity of both the subject matter and the computational processes.

Stock numbered repairable equipment items are returned to the depot for processing when they are categorized as not repairable

at the base level. At the depot some of these items may be condemned; others are repaired, modified or both repaired and modified. Modifications are categorized as either Class IV (reliability, maintainability, or safety) or Class V (performance).

The algorithms estimate the repair and modification costs of repairable items by stock number. Because items are scheduled for efficient processing at depots, the work may take place many months after turn-in. The algorithms estimate costs to be incurred on the basis of depot experience during the current reporting quarter.

In order to verify and validate the CSCS algorithms, a set of analysis procedures applicable to all of the algorithms was established. These procedures were then applied to each algorithm. This report first describes the analysis procedures, without reference to the specific algorithm addressed by this report.

Next, the algorithms are defined and described in detail. This description includes identification of source data systems and files, and the calculation procedures currently implemented by the CSCS.

Finally, a critique of the algorithm is provided as required by the contract. It addresses the following topics:

- Verification of assumptions and approximations for appropriateness and accuracy.

- o Validation of accuracy of source data.
- o Validation of appropriateness of source data as inputs to CSCS logic.
- o Investigation of accuracy and appropriateness of algorithms.
- o Consideration of replacement of indirect cost methods with more direct ones.
- o Identification of algorithm impact on CSCS output reports.

For each algorithm addressed, ISI is required to affirm the process or procedure and reject any portion that cannot be affirmed. Where the algorithm or portion of the algorithm is rejected, an alternate procedure must be specified.

This report affirms the basic methodology for developing base exchangeable repair and modification costs. However, arguments are presented that the depot experience of the currently reported quarter may not be sufficiently representative for algorithm purposes. Recommendations are provided for using the most recent four quarters instead of one quarter for appropriate input data.

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1.0 INTRODUCTION

Visibility and Management of Operating and Support Costs is a program initiated by the Office of the Secretary of Defense (OSD) in order to ensure that each Military Department gathers, tracks, and computes operating and support costs by weapon system (all costs are computed and portrayed in "then year" dollars). VAMOSC II is an Air Force management information system which is responsive to the OSD initiative. It uses information from existing Air Force systems to satisfy both Air Force and OSD needs for certain weapon system operating and support (O&S) costs.

At present, the VAMOSC II system comprises three subsystems:

(1) The Weapon System Support Cost (WSSC) system (D160), which deals with aircraft,

(2) The Communications - Electronics (C-E) system (D160A), which deals with ground communications - electronics equipment,

(3) The Component Support Cost Subsystem (CSCS) (D160B), which deals with subsystems and components for aircraft.

1.1 The Component Support Cost System

The Component Support Cost System (CSCS) of VAMOSC II gathers and computes support costs by assembly/subassembly and relates those costs back to the end item or weapon system. CSCS

replaces the Logistic Support Cost (LSC) model of K051 (AFLCR 400-49) for aircraft and engines.

The objectives of the Component Support Cost System are:

(1) To improve the visibility of aircraft and engine component support costs and to relate those costs to the end item or weapon system.

(2) To improve the Life Cycle Costing capability for the Air Force and the Department of Defense in the acquisition of new weapon systems.

(3) To assist in the design of new weapon systems by providing cost information on components for existing weapon systems thereby enhancing design tradeoff studies.

(4) To provide historical cost information at the weapon system component level to improve logistic policy decisions.

(5) To identify system component reliability, effectiveness, and costs so that high support cost items may be identified and addressed.

The CSCS is described in detail in references [1], [2], and [3]. It receives inputs from 15 Air Force data systems. On a quarterly basis, the system provides two mandatory reports each processing cycle and twelve other types of reports as requested by users. It also provides pre-programmed data base extracts on magnetic tape on a one-time basis in response to user requests.

Special requests for data in user selected format may also be satisfied on a case by case basis.

The twelve reports mentioned above are of primary interest to the user community. They are identified by name in Table 1. Descriptions and samples are provided by reference [1].

At the heart of the CSCS is a set of 30 algorithms for estimation or allocation of costs. The algorithms are identified by name in Table 2. Information Spectrum, Inc. (ISI) was awarded a contract to validate these algorithms. This effort includes investigations of logic, appropriateness of the algorithms, and assumptions inherent in the algorithms. ISI was also to survey published findings, reports of audit, etc. relating to the accuracy of the source data systems. In addition to the algorithm validation, ISI was to perform certain "special tasks," including a user survey.

1.2 Overview of the Algorithm

This report provides the verification and validation of algorithms 12 and 14 of Table 2, "Base Exchangeable Repair Costs (NSN)," and "Base Exchangeable Modification Costs (NSN)." The two algorithms are covered by a single report because the subject matter and the computational processes are similar.

Items sent to the depot for repair or modification are reported by the bases as NRTS (not repairable this station). Because of transportation delays and production scheduling, many

TABLE 1. CSCS OUTPUT REPORTS

NUMBER*	Name
8105	Cost Factors
8104	MDS Logistics Support Costs
8106	Base Work Unit Code (WUC) Costs
8107	Total Base Work Unit Code (WUC) Costs
8111	Depot On-Equipment Work Unit Code (WUC) Costs
8108	Total Base and Depot Work Unit Code (WUC) Costs
8109	NSN-MDS-WUC Cross-Reference
8110	MDS-WUC-NSN Cross-Reference
8112	Logistic Support Cost Ranking, Selected Items
8113	Summary of Cost Elements
8114	NSN-WUC Logistics Support Costs
8115	Assembly-Subassembly WUC Costs

*CSCS output reports are assigned Report control Symbol HAF-LEY (AR)nnnn, where nnnn is the number in the table.

TABLE 2. CSCS ALGORITHM NAMES

1. Base TCTO Labor Cost
2. Base TCTO Overhead Cost
3. Base TCTO Material Cost
4. TCTO Transportation Costs
5. Base Inspection Costs
6. Base Other Support General Costs
7. Base Labor Costs
8. Base Direct Material Costs
9. Base Maintenance Overhead Costs
10. Second Destination Transportation Costs
11. Second Destination Transportation Costs (Engine)
12. Base Exchangeable Repair Costs (NSN)
13. Base Exchangeable Repair Costs (Engine)
14. Base Exchangeable Modification Costs (NSN)
15. Base Condemnation Spares Costs/NSN
16. Base Exchangeable Modification Costs (Engine)
17. Base Supply Management Overhead Costs
18. Depot TCTO Labor Costs
19. Depot TCTO Material Costs
20. Depot TCTO Other Costs
21. Depot Support General Costs
22. Depot Labor Costs
23. Depot Direct Material Costs
24. Depot Other Costs
25. Depot Exchangeable Repair Costs (NSN)
26. Depot Exchangeable Repair Costs (Engine)
27. Depot Exchangeable Modification Costs (NSN)
28. Depot Exchangeable Modification Costs (Engine)
29. Depot Condemnation Spares Costs (NSN)
30. Depot Material Management Overhead Cost

months may elapse from the time an item is turned in at the base until it is worked on at the depot. Moreover, once they leave the base, the items do not retain any identification of the base or aircraft from which they were turned in.

The CSCS develops the expected costs of repairs and modifications of repairable items based on current depot activity for the stock numbered item (NSN) and associates these costs with the turn-ins of NRTS items by NSN, by base and by MDS. First, the system determines the total number of each NSN turned in by base and by SRD as NRTS during the quarter. This count and identification of NRTS items by WUC and by MDS provides the manner in which the costs are related to a particular MDS. These NRTS items by MDS are costed based upon the activity that has taken place for that item at the depot (from H036B) during the same quarter. The number of NRTS items by MDS and WUC is adjusted to account for the expected number condemned at the depot. Next, factors are applied to estimate how many of the remaining items are repaired or modified. Class IV modifications (reliability, maintainability, or safety) and Class V modifications (performance) are treated separately. The resulting counts are multiplied by average repair costs which are developed separately for repairs, Class IV modifications, and Class V modifications for each NSN, yielding the desired results.

2.0 ANALYSIS PROCEDURES

In order to verify and validate the CSCS algorithms, a set of analysis procedures applicable to all of the algorithms was established. These procedures were then applied to each algorithm. This section describes the analysis procedures, without reference to the specific algorithms addressed by this report.

The algorithm analysis process consists of five portions, described in the following sections.

2.1 Algorithm Description

The algorithms are described in references [1], [2], and [3]. These descriptions are not identical. In general they supplement, rather than contradict each other. The first two describe what the system is to achieve; the third describes the system design to do so.

None of these descriptions provides the combination of level of detail and clarity of concept required for this validation effort. The first step in the analysis methodology was the generation of such a description. The descriptions in the three reference sources just cited were made explicit. When necessary, Air Force personnel involved in implementation of the D160B subsystem were contacted for clarification.

2.2 Input Data Definitions

Closely related to the first step was the clarification of the definitions of the input data. The identification of each input data element and of the system providing it was provided by the User's Manual (reference [1]). This identification was refined by identification of a particular file within the source system and the structure of the file as described in both the CSCS System/Subsystem Specification and in the Memoranda of Agreement. The Memoranda of Agreement have been established between the Office of VAMOSC and the Offices of Primary Responsibility (OPR) for the systems providing the input data. Any inconsistencies or voids were identified and resolved through contact with the Office of VAMOSC and/or implementing personnel.

Whenever appropriate, input data element definitions were further refined by tracing the elements back to their sources through the reference data provided. If these were inadequate, the OPRs were contacted directly for clarifications. In tracing the data back to their origins, possible sources of data contamination were considered. Information on the likelihood and significance of such contamination was collected from cognizant personnel and from published references.

2.3 Concept Validation

The two steps above established exactly what the algorithm does. The third, and most critical step, considered the validity of the procedure. It depended on the ability of the analyst to translate mathematical formulas and data processing techniques into meaningful concepts.

Some explicit techniques which were generally used in concept validation are listed below.

(a) Consider how the cost element would be calculated if there were no constraints on resources. (For example, suppose the CSCS could identify the pay grade and hours worked of each individual involved in a maintenance action.)

(b) Identify assumptions* incorporated into the Algorithm. Generally this procedure will identify the real constraints which affect the approach in (a) above.

(c) Identify approximations incorporated into the algorithm. For instance, one such approximation is the use of an average labor rate for each aircraft.

(d) Study each approximation for possible sources of error. Some examples are biases introduced by editing procedures, obsolete data, or inappropriate application. Whenever feasible, estimate the likelihood of these errors by reviews of the literature and contact with cognizant personnel.

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* Note that assumptions, approximations, and allocations are different concepts, although in some cases the boundaries between them are not sharp. ISI has recognized few assumptions in the algorithms, but many approximations and allocations.

(e) Test the algorithms under conditions of assumed extreme values for the inputs. For instance, in evaluating the algorithm for base maintenance overhead costs, assume that for a single reporting period all maintenance labor is overhead and none is direct. Also try the reverse assumption. If an assumption of an extreme input leads to an illogical result, the algorithm is flawed.

Task 4 of Section C-2, c of the contract speaks of appropriate statistical techniques to confirm or repudiate each algorithm. Statistical techniques could confirm or repudiate only statistical hypotheses as assumptions. (Use of an average does not constitute an assumption.) Accordingly, statistical techniques apply to confirmation or repudiation of an algorithm only to the extent that statistical hypotheses can be developed.

(f) As each algorithm is considered, ensure that the costs do not overlap others already accounted for. (In some cases an overlap may be necessary and desirable. Where this occurs, the overlap will be noted.)

(g) In each CSCS output report, identify the data elements incorporating the output of the algorithm, so that a final assessment of report accuracy can be made for each output report.

(h) Consider alternative sources of input data for the

algorithm. Also consider more direct cost assignments than those incorporated in the algorithm.

2.4 Problem Resolution

Whenever a significant deficiency was recognized in one of the algorithms, one or more proposed solutions were developed. This was a creative analytic process for which few guidelines could be proposed in advance. Certainly it depended on familiarity with the various existing Air Force data reporting and processing systems. Proposed solutions were discussed with personnel of the Office of VAMOSC, and revised as appropriate. Recommended solutions were expressed in the form of contributions to a draft Data Automation Requirement (DAR) when these would be applicable.

2.5 Documentation

The documentation of the analysis of each algorithm was a crucial part of the effort. Emphasis was placed on making it thorough, clear, and unambiguous. In the documentation, every assertion was substantiated. This was done by reference to source documentation, by explicitly expressed application of the experience and judgment of the contractor, or by citation of information provided by cognizant Air Force personnel. In the last case, the information was supported by documentation identifying the source, the date, and the information provided.

3.0 ALGORITHM ANALYSIS

The previous section described the general analysis procedures applied to all algorithms. This section presents the results of applying those procedures to the algorithms for Base Exchangeable Repair Costs (NSN) and Base Exchangeable Modification Costs (NSN).

Section 3.1 provides a detailed description of the algorithms and of the input data they use. Section 3.2 provides a critique, structured to correspond to the contractual requirements. Section 4.0 makes recommendations for solutions of problems.

3.1 Algorithm Description

In the following description COBOL-type data names are used to express the algorithm outputs and their components. The available source documentation does not provide the actual data names used by the CSCS programs. They are presumably different from those used in this report.

This description provides formulas for the calculations that are derived from the Users Manual and other sources. They are not the same as the formulas provided in the Users Manual. They are intended to be more explicit. The formulas are stated in Section 3.1.1. The input data elements and their sources are provided in Section 3.1.2. The calculations are described verbally in Section 3.1.3. Unless otherwise noted, the descriptions are based on references [1], [2], and [3], and on direct discussion with personnel of the Office of VAMOSC. In case of any discrepancies, information provided by knowledgeable personnel was accepted as most current, hence most definitive.

3.1.1 Calculations

For purposes of this analysis, it is convenient to express the calculations performed by the two algorithms by ten formulas:

(1) $$\text{SVCBL-PORTN} = \frac{\text{SVCBL-DEPOT} + \text{SVCBL-CONTR}}{\text{SVCBL-DEPOT} + \text{CONDM-DEPOT} + \text{SVCBL-CONTR} + \text{CONDM-CONTR}}$$

(2) AVE-REP-COST = TOT-REP-COST/REP-COUNT

(3) AVE-MOD-IV-COST = TOT-MOD-IV-COST/MOD-IV-COUNT

(4) AVE-MOD-V-COST = TOT-MOD-V-COST/MOD-V-COUNT

(5) REPAIR-FRAC = REPAIR-COUNT/PRODN-COUNT

(6) MOD-IV-FRAC = MOD-IV-COUNT/PRODN-COUNT

(7) MOD-V-FRAC = MOD-V-COUNT/PRODN-COUNT

(8) TOT-REP-COST =
QTY-NRTS x SVCBL-PORTN x REPAIR-FRAC x AVE-REP-COST

(9) TOT-MOD-IV-COST =
QTY-NRTS x SVCBL-PORTN x MOD-IV-FRAC x AVE-MOD-IV-COST

(10) TOT-MOD-V-COST =
QTY-NRTS x SVCBL-PORTN x MOD-V-FRAC x AVE-MOD-V-COST

3.1.2 Inputs

Name: SVCBL-DEPOT

Definition: Number of items of the NSN reported as completed serviceable by organic depot maintenance for the quarter.

Source System/File: G004L/ALIG3C0 (B6D7U0)

Name: CONDM-DEPOT

Definition: Number of items of the NSN reported as condemned by organic depot maintenance for the quarter.

Source System/File: G004L/ALIG3C0 (B6D7U0)

Name: SVCBL-CONTR

Definition: Number of items of the NSN reported as serviceable by contractor for the quarter.

Source System/File: G072D/LOIYHAB

Name: CONDM-CONTR

Definition: Number of items of the NSN reported as condemned by contractor for the quarter.

Source System/File: G072D/LOIYHAB

Name: TOT-REP-COST

Definition: Total of all repair costs at depot level (organic or contractor) for the NSN for the quarter.

Source System/File: H036B/AHMORA1

Name: TOT-MOD-IV-COST

Definition: Total of all costs of Class IV modifications at depot level (organic or contractor) for the NSN for the quarter.

Source System/File: H036B/AHMORA1

Name: TOT-MOD-V-COST

Definition: Total of all costs of Class V modifications at depot level (organic or contractor) for the NSN for the quarter.

Source System/File: H036B/AHMORA1

Name: PRODN-COUNT

Definition: Number of items of the NSN reported as completed at the depot level for the quarter.

Source System/File: H036B/AHMORA1

Name: REPAIR-COUNT

Definition: Number of items of the NSN reported as completed at the depot level and categorized as repair for the quarter.

Source System/File: H036B/AHMORA1

Name: MOD-IV-COUNT

Definition: Number of items of the NSN reported as completed at the depot level and categorized as Class IV modifications for the quarter.

Source System/File: H036B/AHMORA1

Name: MOD-V-COUNT

Definition: Number of items of the NSN reported as completed at the depot level and categorized as Class V modifications for the quarter.

Source System/File: H036B/AHMORA1

Name: QTY-NRTS

Definition: Number of items of the NSN returned to depot as NRTS. Counts are accumulated separately by aircraft (identified by SRD), subsystem or component (identified by WUC), and reporting organization (identified by SRAN).

Source System/File: D143F/B21EA0

3.1.3 Description of Calculation Procedure

The following discussion explains the calculation procedure implicit in the calculations of 3.1.1 as applied to the inputs defined in Section 3.1.2.

In order to understand the logic, it should be recognized that repairable items turned in from the bases as NRTS to the depot are no longer identified with the base or aircraft when they arrive at the depot. All depot systems record transactions

only by NSN. Moreover, they may accumulate at the depot for months before being processed. When they are processed, some of them may be condemned at the depot. Of those that are not condemned, some may be subjected to Class IV modifications, some to Class V modifications, and some repaired. As will be discussed in Section 3.2.4, condemnation, the two classes of modification, and repair essentially constitute all of the depot maintenance transactions (and thus costs) associated with repairable NSNs.

Formula 3.1.1(1) determines the ratio of the number of items (by NSN) completed and serviceable to the total of serviceable and condemned items at the depot level for the quarter. Since the items on which this ratio is based may not be the actual items NRTS'd to the depot in the current quarter, this ratio (called SVCBL-PORTION) is an estimate of the fraction of actual turn-ins which will not be condemned at the depot.

Formulas (2) through (7) of Section 3.1.1 all use data from data system H036B. Table 3, extracted from reference [3], lists the data elements extracted from that system. Other H036B data elements are not relevant to these algorithms. The CSCS selects only H036B records with numeric item identification numbers (element 010 in Table 3). These correspond to valid NSNs. Moreover, only records with an "A" as the first element of the

TABLE 3 H036B DATA ELEMENTS

ELEM NR	LVL NR	LONG TITLE OF DATA ELEMENT (FIRST 50 CHAR)
001	01	INTERROGATION REQUEST TAPE
002	03	TYPE, RECORD
003	03	CODE, QUARTER
004	03	YEAR, FISCAL
005	03	CODE, PROGRAM ELEMENT
006	03	NAME, FACILITY
007	03	CODE, AREA, CONUS OR OVERSEA
008	03	CODE, OWNERSHIP PURPOSE
009	03	CODE, FACILITY, REPORTING
010	03	NUMBER, ITEM IDENTIFICATION
011	03	NOMENCLATURE, ITEM
012	03	PRICE, STANDARD INVENTORY
013	03	CODE, WEAPON SYSTEM SUPPORT
014	05	CODE, WEAPON SYSTEM SUPPORT, POSITIONS 1 TO 3
015	05	CODE, WEAPON SYSTEM SUPPORT, POSITION 4
016	03	CODE, WORK BREAKDOWN STRUCTURE
017	05	CODE, MAJOR COMMODITY GROUP
018	05	CODE, CATEGORY OF WEAPON SYSTEM
019	05	CODE, COMPONENT OF WEAPON SYSTEM
020	03	CODE, WORK PERFORMANCE
021	05	DESIGNATOR, JOB
022	05	FILLER
023	03	CODE, CUSTOMER
024	03	COST, PRODUCTION, DIRECT LABOR, CIVILIAN
025	03	HOURS, PRODUCTION, DIRECT CIVILIAN LABOR
026	03	COST, OTHER, DIRECT LABOR, CIVILIAN
027	03	HOURS, OTHER, DIRECT CIVILIAN LABOR
028	03	COST, PRODUCTION, DIRECT LABOR, MILITARY
029	03	HOURS, PRODUCTION, DIRECT MILITARY LABOR
030	03	COST, OTHER, DIRECT LABOR, MILITARY
031	03	HOURS, OTHER, DIRECT MILITARY LABOR
032	03	COST, FUNDED, DIRECT MATERIAL
033	03	COST, UNFUNDED, DIRECT MATERIAL INVESTMENT
034	03	COST, UNFUNDED, DIRECT MATERIAL EXCHANGE
035	03	COST, UNFUNDED, DIRECT MATERIAL, MODIFICATION KITS
036	03	COST, UNFUNDED, DIRECT MATERIAL EXPENSE
037	03	COST, FUNDED, OTHER DIRECT
038	03	COST, UNFUNDED, OTHER DIRECT
039	03	COST, FUNDED, OPERATIONS OVERHEAD
040	03	COST, UNFUNDED, OPERATIONS OVERHEAD
041	03	COST, FUNDED, GENERAL AND ADMINISTRATIVE
042	03	COST, UNFUNDED, GENERAL AND ADMINISTRATIVE
043	03	COST, CONTRACT OR INTERSERVICE
044	03	COST, GOVERNMENT FURNISHED MATERIAL, INVESTMENT
045	03	COST, GOVERNMENT FURNISHED MATERIAL, EXCHANGE
046	03	COST, GOVERNMENT FURNISHED MATERIAL, MODIFICATION
047	03	COST, GOVERNMENT FURNISHED MATERIAL, EXPENSE
048	03	COST, FUNDED, GOVERNMENT FURNISHED SERVICES
049	03	COST, UNFUNDED, GOVERNMENT FURNISHED SERVICES
050	03	COST, FUNDED, MAINTENANCE SUPPORT
051	03	COST, UNFUNDED, MAINTENANCE SUPPORT
052	03	QUANTITY, PRODUCTION
053	03	FILLER
054	03	QUANTITY, ITEMS INDUCTED REPORTING YEAR
055	03	QUANTITY, ITEMS INDUCTED PREVIOUS YEAR
056	03	QUANTITY, ITEMS INDUCTED ALL PRIOR YEARS
057	03	WORK DAYS IN PROCESS
058	03	CODE, CLASSIFICATION, JOB ORDER NUMBER
059	03	FILLER
060	03	COST, FUNDED, TOTAL
061	03	COST, UNFUNDED, TOTAL

TABLE 3 H036B DATA ELEMENTS (Continued)

ELEM NR	LVL NR	LONG TITLE OF DATA ELEMENT (FIRST 50 CHAR)
062	03	COST, AVERAGE UNIT REPAIR
063	03	NUMBER, PROGRAM CONTROL
064	05	CODE, REIMBURSEMENT
065	05	CATEGORY, REPAIR GROUP
066	05	CODE, PSEUDO
067	07	CODE, AIR LOGISTICS CENTER
068	07	CODE, PSEUDO, LAST 3 POSITIONS
069	03	CODE, STATUS, PRODUCTION
070	03	CODE, MATERIEL MANAGEMENT
071	03	CODE, WEAPON SYSTEM SUPPORT
072	05	CODE, WEAPON SYSTEM SUPPORT, POSITIONS 1 TO 3
073	05	CODE, WEAPON SYSTEM SUPPORT, POSITION 4
074	03	CODE, WORK BREAKDOWN STRUCTURE
075	05	CODE, MAJOR COMMODITY GROUP
076	05	CODE, CATEGORY OF WEAPON SYSTEM
077	05	CODE, COMPONENT OF WEAPON SYSTEM
078	03	NUMBER, JOB ORDER
079	05	NUMBER, CONTROL, 1ST POSITION
080	05	FILLER

Work Breakdown Structure (field 017) are selected. This code identifies aircraft applications.

For the algorithms considered in this report, the third element of the Work Breakdown Structure must be 1, 3, 4, 5, 6, or 7. These codes identify equipment categories other than engines. The CSCS does similar costing for engines, of course, but this is considered in algorithms 13 and 16 of Table 2.

Element 020 of Table 3 is the Work Performance Code. Table 4, extracted from reference [1], identifies the possible entries. Codes A, B, G, I, J, and K are identified by the CSCS as repair actions. Code C identifies Class V and Code H Class IV modifications. Codes D, E, L, and M are not relevant to repair for NSNs. The remaining codes correspond to administration, planning, training, etc., and are not associated with NSN maintenance.

The input identified as TOT-REP-COST is the sum of all applicable costs (see Section 3.2.2) for selected records with Work Performance Codes A, B, G, I, J, or K. REPAIR-COUNT is the sum of the production counts for the same records. Similarly, inputs for Class IV modifications are based on Work Performance Code H, and Class V modifications on Work Performance Code C. The input PRODN-COUNT is simply the sum of the production counts for the three cases.

Thus the average costs of formulas 3.1.1(2), (3) and (4) are simply the quotients of the applicable costs and associated production quantities. Formulas (5), (6), and (7) determine what

TABLE 4 WORK PERFORMANCE CATEGORIES

Code A—Overhaul. The disassembly, test, and inspection of the operating components and the basic structure to determine and accomplish the necessary repair, rebuild, replacement and servicing required to obtain the desired performance. It is considered to be synonymous with the terms "rework" or "rebuild."

Code B—Progressive Maintenance. A predetermined amount of work that presents a partial overhaul under a program that permits the complete overhaul to be accomplished during two or more time periods. It is considered synonymous with the terms "cycle maintenance," "restricted availability," "preventive servicing," or "recondition."

Code C—Conversion. The alteration of the basic characteristics of an item to such an extent as to change the mission, performance or capability.

Code D—Activation. The depreservation, servicing, inspection, test and replacement of assemblies or subassemblies as required to return an item from storage or inactive pool status to operational use.

Code E—Inactivation. The servicing and preservation of an item prior to entering storage or an inactive pool.

Code F—Renovation. The proof and test evaluation and rework of ammunition or ordnance items as required for retaining their desired capability.

Code G—Analytical Rework. The disassembly, test and inspection of end-items, assemblies or subassemblies to determine and accomplish the necessary rework, rebuild, replacement, or modification required. It includes the technical analysis of the findings and determination of maintenance criteria. Includes prototype tear-down, analysis and rework of an item to determine job and material specifications on a future workload.

Code H—Modification. The alteration or change of the physical makeup of a weapon/support system, subsystem, component, or part in accordance with approved technical direction.

Code I—Repair. Action taken to restore to a serviceable condition an item rendered unserviceable by wear, failure, or damage.

Code J—Inspection and Test. The examination and testing required to determine the condition or proper functioning as related to the applicable specifications.

Code K—Manufacture. The fabrication of an item by application of labor and/or machines to material.

Code L—Reclamation. The authorized processing of end-items, assemblies or subassemblies to obtain parts or components that are to be retained in the inventory prior to taking disposal action on the remaining items. Covers demilitarization actions on items prior to disposal when the demilitarization is incidental to the reclamation.

Code M—Storage. The inspection, represervation and maintenance in a storage status of weapons and equipment items as well as their subsystems and components in the supply system.

Code N—Technical Assistance. The use of qualified depot maintenance personnel to provide technical information, instructions, or guidance, or to perform specific work requiring special skills, for operational activities or other maintenance organizations. Includes all demilitarization other than the incidental to reclamation (Code L).

Code O—Not Used.

Code P—Programming and Planning Support. Includes consolidated long-range workload scheduling and resource utilization; centralized maintenance programming and planning for support of all levels of maintenance; all logistics support exclusive of engineering effort in the programming and development of maintenance support requirements for weapon systems and weapons support activities.

Code Q—Maintenance Technical and Engineering Support. Includes the technical and engineering effort in development of maintainability concepts and the maintenance portion of logistics plans dealing with future and present weapons and equipment. Includes regional maintenance representatives, field liaison, maintenance technicians, contract technical services, contract engineering services in direct support of maintenance, contract technicians and engineers in direct support of maintenance.

Code R—Technical and Engineering Data. Includes the preparation of technical and engineering data as applied to all categories of equipment. Includes engineering drawings, wiring diagrams, technical orders, engineering technical standards, technical handbooks, technical bulletins and similar publications. Provides for the preparation, editorial review and/or revision of equipment publications pertaining to the operation, repair and repair parts support of DOD materiel. Preparation includes, but is not limited to, the consolidation of source data, drawings and art work, editing, preparation of final printable copy and printing. Includes significant identifiable effort within organic maintenance or at other DOD specialized support functions to produce data in support of maintenance, such as cryptographic or test equipment support data.

Code S—Technical and Administrative Training. In

TABLE 4 WORK PERFORMANCE CATEGORIES (Continued)

c ...ies educational units conducting maintenance training and training associated with new weapon systems or support systems which have been or will be introduced into the DOD inventory. At depot maintenance activities, only training associated with new equipment is maintenance support. This training is separately funded by specific funding documents. Other training accomplished at depot maintenance activities in support of the depot maintenance operation is not maintenance support, but a part of the depot maintenance operation.

Code T—Nonmaintenance Work. Used to assure completeness of maintenance work force reporting.

fractions of the total production were repairs, Class IV modifications, or Class V modifications in the currently reported quarter. The total production count of the NSN (including both modifications and repairs) is the common denominator of these fractions, so the fractions add up to one.

Formulas (8), (9), and (10) all begin by multiplying the quantity of NRTS turn-ins by a fraction representing the portion not condemned in the currently reported quarter. The result is an estimate of the number of these items which will not be condemned. This result is multiplied by the appropriate fraction to estimate the number repaired or modified in each case. Finally, these estimates are multiplied by the applicable average unit costs (repair, modification IV or modification V costs) to yield estimates of exchangeable repair costs (TOT-REP-COST), Class IV modification costs (TOT-MOD-IV-COSTS), and Class V modification costs (TOT-MOD-V-COSTS). Since the NRTS counts are accumulated separately by MDS, WUC, and base, the resulting cost estimates are similarly identified.

3.2 Critique of Algorithm

This section addresses various facets of the two algorithms. The discussion is structured to correspond to the contractual requirements. Each aspect is either affirmed or rejected. Rejections lead to recommendations in Section 4.0.

3.2.1 Appropriateness and Accuracy of Assumptions and Approximations.

Information Spectrum has identified two approximations used in these algorithms. They are addressed separately below.

There is a basic underlying assumption in these algorithms which assumes that for each NSN NRTS'd from a base there will be depot repair activity each quarter from which to determine costs and production ratios. This assumption is not always valid, and recommendations are necessary to describe procedures that will be effective in those cases for which the assumption is not valid.

As a matter of practice, work on some NSN items that are common to both aircraft and other systems are sometimes recorded at the depot under Work Breakdown Structure (WBS) code "L" (meaning "all other items"). When this occurs, the costs and production counts for the NSN cannot be identified to a repair or modification. The experience of cognizant Air Force personnel is that the frequency of this occurrence is small, so the impact of not including these data in the computation of NSN repair or modification costs is considered negligible. It remains, however, an underlying assumption that this occurrence is small. The only way to obviate this assumption is to forbid (by policy or authoritative statement) the practice of recording repairable NSN maintenance by WBS code "L".

3.2.1.1 Disposition of NRTS Turn-Ins

In general, items turned in as NRTS by the bases will eventually be condemned, modified, or repaired at the depot. The number which will be condemned is not known at the time of the turn-in. Items to be modified are tagged, but their numbers are not entered as needed into Air Force data systems. Accordingly, it is appropriate to estimate the portions disposed of in each way by an approximation based on experience.

However, ISI feels that the use of the ratios from the currently reported quarter is undesirable. Depot activities for a given NSN are commonly scheduled only when an economic quantity of the NSN is available. Lack of funds to pay for the repair/modification (or condemnation determination) may also cause only periodic depot activity. Thus it would be expected that a selected NSN modification might not appear at all for several quarters, and then a batch of them would occur. Repairs and condemnations could show similar effects, because the items might not be inducted into a production line for several quarters. Thus, the quarterly proportions of items condemned, modified, or repaired could fluctuate excessively or even create a zero value for these proportions. Thus, actual NRTS items might produce no costs in CSCS output reports because the factors of the computations of Section 3.1.1(8), (9) and (10) might contain zero values. Section 4.0 recommends a change in procedure.

3.2.1.2 Time Period for Cost Averages

The average cost per item is simply the average cost which prevailed in the currently reported quarter. Exactly the same scheduling considerations discussed above in Section 3.2.1.1 apply here. It may be expected that these quarterly average costs will show fluctuations (or periods in which no costs are accrued) which are not representative of the costs expected to apply to turn-ins. The recommendation of Section 4.0 addresses this problem also.

3.2.2 Accuracy of Source Data and Congruence of Data Element Definitions

Information Spectrum was directed to validate accuracy of source data based on a survey of published findings, reports of audit, etc. No direct sampling of data was to be performed. The Office of VAMOSC has indicated that direct validation of source data is planned for future efforts.

As indicated in Section 3.1.2, the input data is provided to the CSCS by data systems G004L, G072D, H036B, and D143F. No published criticism of the accuracy of any of these data systems could be found. Accordingly, ISI affirms their accuracy.

Next we address the congruence between definitions of input data elements as used by the CSCS and as provided by the input data systems.

3.2.2.1 Serviceable/Condemnation Counts

The counts of items serviceable and condemned by the depot and by the contractor are defined in Attachment A of reference [3]. These definitions are straightforward and correspond to their application by the CSCS.

3.2.2.2 Repair Costs

The total repair cost used by the CSCS is the sum of all applicable cost elements available from H036B. Table 3, extracted from reference [3], lists the data elements extracted from that system. In that table, elements numbered 024, 026, 028, 030, and 032 through 051 are the data elements that provide costs. All costs that are also coded by a repair WPC (see Table 4) are summed by the CSCS to yield the total repair cost. These cost categories derive from reference [29], which implicitly requires that all depot maintenance costs for the military departments be identified by those categories.

It may be noted that the listing of H036B data elements in reference [1] omits data elements 042, 043, and 050. Reference [3] is more accurate.

It may also be noted that the H036B cost elements include both funded and unfunded costs, and that they include cost elements not used in the calculation of standard depot repair prices (sales prices). ISI affirms the congruence of the definitions of repair prices as provided by H036B and as used by the CSCS, with the proviso that users of CSCS output data should be clearly informed of the nature of the cost elements included.

3.2.2.3 Production Counts

Section 3.1.3 of this report explained how production counts represent completed depot level actions categorized by the nature of the work done. The resulting counts are straightforward, and ISI affirms the congruence of the input definitions and the CSCS interpretations.

3.2.2.4 NRTS Turn-Ins

Items turned in as NRTS at bases are routinely reported via the AFRAMS (Air Force Repairable Asset Management System) Daily Change Report described in Attachment A-2 of reference [25]. These reports are accumulated to yield the turn-in counts. ISI affirms the congruence of the input data definition with the CSCS interpretation.

3.2.3 Appropriateness of Source Data as Inputs

Section 3.1.2 showed that depot production data is provided by the G004L system. Contractor production data comes from G072D. Repair costs and counts come from H036B, and NRTS turn-in counts from D143F. Review of the documentation of these systems indicates that they are designed to provide just this sort of information to users. ISI affirms their appropriateness.

3.2.4 Accuracy and Appropriateness of Algorithms

It has been stressed in previous discussion that items turned in to the depot as NRTS cannot later be identified as to their source. Moreover, processing of these items by the depot may take place months (even years) after their turn-ins. Yet, it is desired to develop repair and modification costs associated with

the time of turn-in. Under these circumstances it is appropriate to associate representative costs with the turn-ins, as is done by the algorithms. Information Spectrum affirms the appropriateness of the approach.

The accuracy would be satisfactory if the estimates of the proportions of items repaired, condemned and modified were representative, and if the associated costs were also. Section 3.2.1 presented arguments suggesting that this may not be the case. Accordingly, we provide recommended changes in Section 4. If these are implemented, we believe the accuracy of the algorithms will be satisfactory.

3.2.5 Directness of Costing

Having acknowledged that the repair cost of items NRTS'd to the depot must be based on representative, not actual depot cost values, it is appropriate here to consider whether the representative depot costs are direct. Discussion with Air Force personnel indicates that cost elements in H036B are as direct as feasible. For instance, direct labor and material costs are directly identified with the item being worked on, and are so reported. Overhead, and general and administrative (G&A) costs are generally accrued at the Air Logistics Command or Resource Control Center level, and then allocated to the direct labor tasks. Reference [29] requires that operations overhead costs be allocated in proportion to direct labor hours. Indirect costs coded in H036B are allocated to NSNs "in proportion to benefits received," and G&A costs are allocated in proportion to the total of direct and indirect costs. Information Spectrum, Inc. affirms the directness of costing used in these algorithms.

3.2.6 Application to CSCS Output Reports

The costs addressed by these algorithms relate to NSN items turned in by bases. They should not be confused with similarly titled costs associated with work on the entire aircraft or engine at the depot.

The costs generated by these algorithms impact elements of six CSCS reports as described by Table 5. The accuracy and limitations described for the algorithms by this report impacts certain elements of the CSCS reports listed in Table 5. The total accuracy of each report cannot be addressed until all algorithms impacting the report and its respective cost elements have been reviewed. This will occur in the final report of this effort. Evaluation of the usefulness of the reports will also be provided in the final report of this effort and after ISI conducts a survey of users.

TABLE 5

CONTRIBUTION OF BASE EXCHANGEABLE REPAIR COST AND BASE EXCHANGEABLE MODIFICATION COST ALGORITHMS TO CSCS OUTPUT REPORTS

OUTPUT REPORT/NUMBER(1)	COST ELEMENTS CONTRIBUTED(2) TO BY THE ALGORITHM
1. Base Work Unit Code (WUC) Costs/8106	1. By base and MDS: WUC COSTS a. EXCH REPAIR b. EXCH MOD IV c. EXCH MOD V d. TOTAL WUC
2. Total Base Work Unit Code (WUC) Costs/8107	2. By MDS for all bases: WUC COSTS a. EXCH REPAIR b. EXCH MOD IV c. EXCH MOD V d. TOTAL WUC
3. Total Base and Depot Work Unit Code (WUC) Costs/8108	3. By MDS and WUC for all bases: a. BASE EXCH REPAIR COSTS (1) REPAIR (2) MOD IV (3) MOD V b. BASE & DEPOT WUC TOTAL

(1)CSCS output reports are assigned Report Control Symbol HAF-LEY (AR) nnnn, where nnnn is the number in the table.

(2)Capital letters indicate the titles printed on the report.

TABLE 5 Continued

OUTPUT REPORT/NUMBER[1]	COST ELEMENTS CONTRIBUTED[2] TO BY THE ALGORITHM
4. Summary of Cost Elements/8113	4. By MDS for all bases: a. COMPONENT REPAIR, BASE EXCH REPAIR COST b. CLASS IV MODIFICATIONS,[3] BASE EXCH MOD COSTS (1) LABOR (2) OTHER c. SUSTAINING INVESTMENT, MODIFICATION KITS, BASE EXCH MOD COSTS, CLASS IV
5. NSN-WUC Logistics Support Cost/8114	5. By NSN, MDS, and WUC for all bases: a. BASE COSTS (1) EXCH REPAIR (2) EXCH MOD (CL IV) (3) EXCH MOD (CL V) b. TOTAL NSN
6. Assembly-Subassembly WUC Costs/8115	6. By MDS and WUC for all bases: a. BASE EXCH REPAIR COSTS (1) REPAIR (2) MOD IV (3) MOD V b. BASE & DEPOT WUC TOTAL

[1] CSCS output reports are assigned Report Control Symbol HAF-LEY (AR) nnnn, where nnnn is the number in the table.

[2] Capital letters indicate the titles printed on the report.

[3] Report is erroneously labeled; it shows combined costs of Class IV and Class V modifications.

4.0 Recommendations

Section 3 has presented an assessment that the algorithms for base exchangeable repair costs (NSN) and base exchangeable modification costs (NSN) are fundamentally sound. Two procedural weaknesses were identified in Section 3.2.1. The recommendations in Section 4.1 and 4.2 address these weaknesses. In addition, it is recommended that the office of VAMOSC initiate an effort to eliminate the practice of depots recording maintenance activity on certain NSN's by WBS code "L". This practice appears arbitrary and creates an unwarranted uncertainty (though small) on the results of fundamentally sound algorithms.

In the Air Force Logistics Command, changes to automated data systems are initiated through preparation of AFLC Form 238, "Data Automation Requirements," (DAR). This form contains a number of administrative entries, together with three items of substantive content: "Requirements," "Impact Statement," and "Justification Benefits/Cost Savings." Attachment 1 provides a draft of these sections appropriate to the recommendations in Sections 4.1 and 4.2 below. It is appropriate to address both recommendations by a single DAR.

4.1 Recommendation for Depot Production and Condemnation Counts

In section 3.1.1, formula (1) uses inputs identified as SVCBL-DEPOT, CONDM-DEPOT, SVCBL-CONTR, and CONDM-CONTR. Formulas (5), (6) and (7) use inputs identified as REPAIR-COUNT, MOD-IV-COUNT, MOD-V-COUNT, and PRODN-COUNT. Section 3.1.2 identified each of these inputs as a count of activities for the current quarter.

It is recommended that each of these definitions be changed so that the input quantity is the accumulated count for the most recent four quarters. Note that use of four quarters would avoid any seasonal biases.

It is conceivable that no counts would be accumulated for some class of data even over a full year. Accordingly, the following rule is recommended for formulas (1), (5), (6), and (7) of Section 3.1.1. If the denominator in the formula is zero, the value used in the previous quarterly processing cycle should be re-used in the present processing cycle.

4.1a Office of VAMOSC (OOV) Comments

Concur. The use of data for the current quarter only for computation of depot repair, modification and condemnation percentages may cause some distortion of the data when activity is low for a particular NSN. By using accumulated counts for the most recent four quarters to compute the percentages, we should portray more accurately the costs associated with depot maintenance. A DAR requesting this change will be prepared and submitted by 31 May 84.

4.2 Average Costs

In Section 3.1.1, formulas (2), (3), and (4) calculated average depot costs for repair, CLass IV modification, or Class V modification of an NSN based on cost data from the current quarter. It is recommended that if the denominator is zero in any of these formulas, the value used in the previous quarterly processing cycle be re-used in the current processing cycle, and adjusted for inflation as follows:

(1) From AFR 173-13, select the USAF raw inflation indices for O&M for the current year and the previous year.

(2) Subtract the index for the previous year from the index for the current year. Divide the result by 4, then add 1.

(3) The result is an approximate quarterly O&M inflation index.

(4) Multiply any average depot cost carried forward (because of no applicable depot activity in the current quarter) by this index.

More elaborate inflation adjustments can be imagined. The costs of labor, materials, and overhead could be adjusted separately. A quarterly inflation factor defined as the fourth root of the ratio of the annual factors would be infinitesimally more precise. Such refinements would entail significant procedural complications. Information Spectrum judges that the results would not justify the additional effort.

4.2a Office of VAMOSC (OOV) Comments

Concur. The current method used to compute average depot repair and modification costs relies on the assumption that repair/modification takes place for every NSN in every quarter. In the event that no such activity takes place for a particular NSN in a particular quarter, the average repair/modification cost will equal zero. Our reports will then show no costs for the quarter regardless of the number of NRTS actions reported over

the D143F system. Using the figure for the previous quarter and adjusting for inflation should alleviate this problem. A DAR requesting this change will be prepared and submitted by 31 May 84.

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[6] Memoranda of Agreement (listed separately)

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MEMORANDA OF AGREEMENT
FOR SYSTEM INTERFACES

Ref. No.	Memorandum No.	Date
[6.1]	D002A/M024B/D160B-A	9 Jun 1980
[6.2]	D002A/M024B/D160B-B	9 Jun 1980
[6.3]	D024A/D160B-A	30 Jun 1980
[6.4]	D033./ARC/D160B	14 Jun 1980
[6.5]	D042A/DNB/D160B	4 Nov 1983
[6.6]	D046/M024/D160B	9 Apr 1981
[6.7]	D046/D160B	23 Jun 1982
[6.8]	D056A/BDN/D160B-A	23 Jan 1981
[6.9]	D056A/D160B-C	13 Oct 1981
[6.10]	D056A/D160B-D	29 Jan 1981
[6.11]	D056A F005	25 Apr 1979
[6.12]	D056B/BDN/D160B-A	22 Dec 1980
[6.13]	D056C/D160B-A	4 Mar 1981
[6.14]	D071/D160B	17 Jun 1982
[6.15]	D143B/D002A 9159	3 Aug 1979
[6.16]	D143F/ARC/D160B-A	5 Feb 1981
[6.17]	D160/D160B	11 Jun 1982
[6.18]	G004L/M024B/D160B-A	30 May 1980
[6.19]	G004L/M024B/D160B-B	30 May 1980
[6.20]	G004L/M024B/D160B-C	5 Nov 1981
[6.21]	G019F/D160B	8 Sep 1982
[6.22]	G033B/D160B	12 Jul 1982
[6.23]	G072D/BDN/D160B-A	19 Apr 1982

MEMORANDA OF AGREEMENT
FOR SYSTEM INTERFACES (Continued)

Ref. No.	Memorandum No.	Date
[6.24]	H036B/RC/D160B-A	10 Feb 1981
[6.25]	H069R/M024B/D160B-B	19 Jan 1981
[6.26]	0013/BDN/D160B	22 Jul 1982

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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)

VAMOSC
O&S Costs
Cost Allocation

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

This study is the ninth of a set of reports documenting the findings of a study conducted by Information Spectrum, Inc (ISI) for the Office of VAMOSC, Air Force Logistics Command, This study constitutes an assessment of the algorithms for Base Exchangeable Repair and Modification Costs (National Stock Number) within the Component Support Cost System (CSCS) subsystem of VAMOSC, the Air Force Visibility and Management of Operating and Support Cost System. CSCS deals with subsystems and components for aircraft.

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20. This report combines the two algorithms because of the similarity of both the subject matter and the computational process. These algorithms estimate the repair and modification costs of repairable items by national stock number (NSN). Because items are scheduled for efficient processing at depots, the work may take place many months after turn-in. The algorithms estimate costs to be incurred on the basis of depot experience during the current reporting quarter.

This volume presents ISIs conclusions and recommendations, and the comments of the Office of VAMOSC.

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