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8 December 1978
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MILITARY STANDARD

COMMAND, CONTROL AND COMMUNICATIONS (C^3) SYSTEM & COMPONENT FAULT DIAGNOSIS, SUBSYSTEMS, ANALYSIS/SYNTHESIS OF

FSC MISC

MIL-STD-001591A (USAF)
8 December 1978

ROME AIR DEVELOPMENT CENTER

DEPARTMENT OF THE AIR FORCE

GRIFFISS AFB NY 13441

Command, Control and Communications (C^3) System & Component Fault Diagnosis, Subsystems, Analysis Synthesis of

1. This limited coordination Military Standard has been prepared by the Rome Air Development Center based upon currently available technical information, but it has not been approved for promulgation as a coordinated revision of MIL-STD-1591. It is subject to modification. However, pending its promulgation as a coordinated Military Standard, it is mandatory for use by the Department of the Air Force when invoked by the contract.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Rome Air Development Center, RBRD, GAFB NY 13441 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

I. SCOPE

1.1 Purpose: This standard establishes uniform criteria for conducting trade studies to determine the optimal design for command, control and communication system and component fault diagnosis/isolation subsystems, hereafter referred to as Fault Identification & Test Subsystems (FITS). FITS include the hardware and/or software necessary for the detection and isolation of failures.

1.2 Application: This standard is applicable to Electronics Systems Division procurements which include the development of fault/detection isolation/ diagnosis and test subsystems where:

a. Selections can be made among such alternatives as centrally controlled system built-in-test, individual system component (equipment) ouilt-in-test, equipment subunit built-in-test, special purpose external test subsystems and testers or combinations of the preceding.

b. Different design and/or architectures exist for each alternative. Such subsystems are inclusive of system/equipment operational level fault detection coupled with built-in-test, and external test subsystems, as well as shop and depot level applicable built-in-test and testers.

II. REFERENCED DOCUMENTS

2.1 The following documents of the issue in effect on the date for invitation for bids or requests for proposal form a part of this standard to the extent specified herein (see 6.0).

Publications:

RADC-TR-69-140, Test Instrumentation Requirements and Techniques for Advanced Systems

RADC-TR-71-281, Design of Integral Sensor Test System

MIL-STD-470 (ESD Amended Version), Maintainability Program Plan

RADC-TR-74-308, Maintainability Engineering Design Notebook, Revision II, and Cost of Maintainability

(Copies of publications required in connection with specific procurement functions should be obtained from the procuring activity, or as directed by the contracting officer).

III. DEFINITIONS AND ABREVIATIONS

3.1 Line Replaceable Unit (LRU): A Line Replaceable Unit, generally modular in form, designed to facilitate an on-line remove and replace maintenance concept at the organizational level of maintenance. It may include smaller modules, such as circuit cards, within it to facilitate off-line replacement or it can itself be the lowest level of replacement such as a circuit card.

3.2 Primary System: The equipment essential to the performance of the basic mission as distinguished from equipment performing a test or monitor function.

3.3 On-Line: An operation performed on the operational system/equipment.

3.4 Off-Line (Test): An operation performed on a unit removed from its operational environment or equipment (in a shop or depot).

3.5 Sensor: A device designed into the prime equipment that converts a particular parameter of the prime equipment into a form that can be transmitted external to the equipment or to other points within the equipment.

3.6 Test Point: The point in a prime equipment where a sensor is placed or where test equipment is attached to perform measurements.

3.7 BIT: Built-in-Test.

3.8 FMEA: Failure Modes and Effects Analysis.

3.9 FITS: Fault Identification and Test Subsystem. The system and/or component fault diagnosis/isolation subsystem.

IV. GENERAL REQUIREMENTS

4.1 Required Parameters: The contractor shall perform trade studies to determine FITS design for most cost-effective maintenance consistent with performance and operational requirements over the life cycle. The studies* shall include the following considerations:

a. Contract requirements.

b. Failure modes and effects.

c. Alternate system configurations.

d. Alternate diagnosis/isolation methods.

e. Life cycle cost.

f. Standardization of hardware and software.

4.2 Sequence of Work: The contractor shall analyze the contract requirements to determine the required system capability and the constraints on his design. The contractor shall generate or obtain reliability information and a failure modes and effects analysis from the configuration of the primary system or equipment to be handled by the FITS (including alternative configurations of the primary system, if any). This information shall be combined to determine feasible options for the concepts to be used in designing the FITS. Necessary degrees of detail regarding the complexity, reliability, design characteristics and costs of each option shall be developed as inputs to the preceding. These shall be developed by the contractor to the level required for each option. If desired, a modified form of the design synthesis procedure (see 5.3) may be used for this purpose. A cost analysis shall be

*Studies and analyses necessary as an input, and common to this and other standards, shall be combined such that a comprehensive single study or analysis, will be capable of meeting required needs.

performed on the options to determine their life cycle costs, and the most cost-effective option selected (subject to procuring activity approval). The reliability and FMEA data shall then be used with the selected option to synthesize a detailed design for the FITS, implementing the selected concept in the most cost-efficient manner.

4.3 Sensitivity Analysis: All analyses performed will be subjected to a sensitivity analysis to determine the effects of possible uncertainties in the input data on final results. The results of sensitivity analysis shall be considered in the evaluation and final design selections. A narrative shall be provided to the procuring activity at the time of final design selection which outlines the potential impacts of such uncertainties on final design performance and cost.

V. DETAIL REQUIREMENTS

5.1 Determination of Conceptual Options: The contractor shall formulate conceptual options for the design of the FITS from the following inputs:

a. Contractual requirements.

b. Primary system configuration.

c. Primary system reliability data.

d. Primary system FMEA.

e. Maintenance and support concept (or alternatives).

5.1.1 Contractual Requirements: The contractual requirements shall be used to:

a. Define FITS design boundaries using such constraints as size and weight, false alarm rates, etc.

b. Define the fault diagnostic and maintenance capabilities which the FITS shall provide such as:

(1) Maintainability and/or other maintainability oriented requirements as time limitations for fault isolation, mean-time-to-repair, or maintenance man-hours per operating hour, etc.

(2) Minimum proportion of equipment failures identifiable by FITS.

(3) Fault indication requirements.

c. Establish special installation environmental conditions (location, access, temperature, etc.) of the primary system which would impact choice of FITS options.

d. Establish reliability requirements for the FITS to meet its mission.

5.1.2 Primary System Configuration: The primary system configuration shall be used to:

a. Determine system(s), subsystem(s), configuration items/equipments and LRUs to which FITS will apply.

b. Define the size and function of the system, subsystem configuration items/equipments and LRUs.

c. Determine the amenability of the system, subsystems, configuration items/equipments/software to various diagnostic concepts.

d. Determine commonality and redundancy within the system.

e. Provide information for reliability, FMEA and maintainability analysis.

5.1.3 Reliability and FMEA Data: Reliability and FMEA data on the primary system shall be used to:

a. Determine the relative frequency of failure of each LRU and LRU component.

b. Determine the criticality of failures.

c. Determine the effects of failure to:

(1) Establish the difficulty of diagnosis.

(2) Determine possible methods of diagnosis.

The level to which FMEA shall be performed is dependent on the level to which the FITS will apply. If, for example, the FITS design applied to isolation of a failed LRU, the FMEA would be primarily associated with the outputs of each LRU. If the FITS design applied to isolation to a printed circuit board within an LRU, the FMEA would be primarily associated with the outputs of each printed circuit board. An FMEA applied to the component part level is acceptable to any level of FITS application.

5.1.4 Formulation of Options: The information provided by items discussed in paragraphs 5.1.1 through 5.1.3 shall be used for formulating feasible options for the FITS which may include:

a. Test points used in conjunction with manual general usage test equipment, such as voltmeters, oscilloscopes, etc.

b. Integral fault sensors which detect a failure and transmit a signal to an automatic diagnostic routine or manual test point.

c. Indicators measuring key parameters or the output of integral fault sensors which must be monitored and interpreted by the operator (e.g., panel meters).

d. Go/no-go indicators, such as lamps, which indicate a fault in a designated location based on the levels of system signals or integral fault sensors.

e. Computer driven interrogation of the system with results deployed on go/no-go indicators, using a small dedicated computer which shall be provided with the FITS.

f. Computer driven system diagnosis, using a special fault computer or a general purpose computer which shall be included in the primary system with results displayed on cathode ray tubes, teletype printers, etc. The display shall be capable of programming and indicating the specific failed assembly or unit to be replaced.

g. Computer diagnostic routines which effect self-repair by identifying faulty units and switching in redundant units or programming system operation around faults.

h. External test systems, equipment and testers which are designed specifically to provide the capability required, or which by virture of their design may be modified (or programmed) to provide the capability required.

i. Any combination of the above.

5.1.5 Cost Analysis Data: Analysis shall be performed to provide estimation of cost relative to the implementation of each FITS design alternative. Cost estimates shall be developed relative to development, production and support costs (manpower and hardware associated) for each design alternative to the extent required for exercise of the cost model described in paragraph 5.2.1.2.

5.1.6 Government Provided Data: The government will assist the contractor in obtaining basic supporting information and data necessary for the computation of parameters, quantities, and terms contained in, and necessary to the exercise of, analysis/synthesis models and procedures. Such information and data will represent the best estimates available at the time for the purposes of analysis/synthesis. Examples of such information and data include expected operational hours per year and cost per maintenance man-hour.

5.2 Selection of Best Conceptual Option: The most cost-effective option (taking into account both performance and cost) shall be selected from the conceptual options formulated for the design of the FITS. Determination of the most cost-effective option shall be required by use of the model specified herein (paragraph 5.2.1 and subparagraphs). However, other models which consider all the appropriate variables of the model presented herein (or any other appropriate variables) may be used subject to approval of the procuring activity.

5.2.1 Selection Models: The following paragraphs provide a cost model for evaluating FITS options. A model is also provided for computing maintenance man-hour requirements, since this is a parameter of interest and one which may be a constraint.

5.2.1.1 Terms Used in the Models: (Note: The models and procedures included herein are applicable to the evaluation, analysis, and synthesis of built-in-test, as well as special purpose external test systems and testers appropriate to organizational, shop, and depot use. Therefore, depending on the level of maintenance pertinent to the use of a particular FITS, diagnosis and isolation may occur among LRUs, printed circuit cards, assemblies, subassemblies, or component parts. In the definition of terms which follow, let LRUs* = LRUs, printed circuit cards, assemblies, subassemblies or component parts, whichever is appropriate, whichever pertains to the particular level of maintenance in question).

a. λ_I = Failure rate of FITS (based on components of FITS not needed for prime equipment function).

b. λ_{PE} = Total failure rate of prime piece(s) of hardware to which FITS is intended to be applied per system/equipment (does not include failure rate of parts belonging uniquely to FITS).

c. A = Average number of LRUs* to which the FITS isolates. (This may be derived in a variety of ways depending on the fault isolation/ diagnostics subsystem characteristics and the LRU* partitioning design). A suitable formulation determining the necessary or target value of (A) shall be developed by the contractor taking into account relative frequency of LRU* failure, maintenance time constraints and considerations, fault isolation procedures and other characteristics considered during predesign analysis, subject to the approval of the procuring activity.

d. C_{aux} = Total cost of any auxiliary test or maintenance equipment, external to FITS, required to support or complete fundamental FITS tasks. (For example, a supplemental piece of test equipment necessary to complete a fault isolation task).

e. C_{maux} = Cost per year of maintaining all required auxiliary test or maintenance equipment.

f. C_D = Development cost of FITS.

g. C_P = Average production cost of FITS (the average cost of a single FITS unit or cost of the FITS portion of a single unit).

h. C_{MH} = Cost/maintenance man-hour.

i. C_{FD} = Average cost to determine failure has occurred. In some cases the incidence of failure is evident even though FITS is incapable of detecting same. For these cases C_{FD} = 0. Taking the other extreme, failure may remain undetected until primary system mission commitment and so cause mission abort or failure. In that case C_{FD} = estimated average cost of mission abortor failure.

j. C_{IFMA} = Average total cost/FITS failure (material, spares, etc.) excluding direct manpower.

k. C_{IFMP} = Average total man-hours required to repair a FITS failure.

l. MMH_i = Average maintenance man-hours required for fault isolation/ detection by FITS. (NOTE: If fault isolation/detection is fully automatic MMH_i = 0).

m. MMH_S = Average maintenance man-hours per failure required to complete isolation (to determine which of the LRUs* identified by FITS is the manfunctioning unit). This value can be calculated by various means depending on the provisions for troubleshooting/diagnosis provided:

(1) If isolation is to be done by randomly testing or replacing (A) LRUs*:

$$MMH_S = \frac{A}{2} MMH_{sa}$$

where

MMH_{sa} = Average maintenance man-hours required to determine that any given LRU* is operating or failed.

(2) If a sequential troubleshooting guide is provided, the value of MMH_S shall be calculated taking into account the average man-hours required to take each troubleshooting action, the relative probabilities of failure of each of the individual LRUs* and the troubleshooting sequence. When FITS is designed to isolate to a unique LRU*, MMH_S, equals 0.

n. MMH_{RP} = Average maintenance man-hours required for manual troubleshooting to isolate to a LRU* in the event FITS cannot perform isolation.

o. MMH_{PM} = Average maintenance man-hours per FITS preventive maintenance (PM) action (provided PM applicable to FITS).

p. N = Number of units of FITS or units containing FITS produced.

q. N_F = Average number of units of FITS or units containing FITS in field use at any time.

r. N_0 = Number of complete systems/equipments deployed.

s. P_F = Proportion of prime equipments' (LRUs*) faults not isolatable by applicable FITS.

t. P_0 = Proportion of prime system/equipment failures not detectable.

u. T_{PM} = Operational hours between preventive maintenance for FITS.

v. T = Operational hours/unit FITS/year.

w. T_0 = Operational hours per system, equipment or prime piece(s) of hardware that FITS directly serves (per year).

x. Z = Number of years system/equipment is contemplated to be in service (service life).

5.2.1.2 Cost Model

Cost of any FITS alternative =

$$C_D + NC_P + C_{aux} + ZC_{maux} +$$

$$(1-P_F)\left[N_o\lambda_{PE}T_oZ\ (MMH_i + MMH_s)\right]\ C_{MH} +$$

$$P_F\left[N_o\lambda_{PE}T_oZ\right]\left[(MMH_{RP})\ (C_{MH})\right] + P_o\left[N_o\lambda_{PE}T_oZ\right]C_{FD}$$

For shop or depot level FITS $C_{FD} = 0$

$$N_F\lambda_I TZ\left[(C_{IFMA} + C_{IFMP}\ (C_{MH})\right] +$$

$$\frac{N_F TZ}{T_{PM}}\ (MMH_{PM})\ \left[C_{MH}\right]$$

5.2.1.3 Maintenance Manpower Model for FITS:

Taking into account direct maintenance man-hours only, total maintenance man-hours =

$$(1-P_F)\left[N_o\lambda_{PE}T_oZ\ \ (MMH_i + MMH_s)\right] + P_F\left[N_o\lambda_{PE}T_oZ\ (MMH_{RP})\right] +$$

$$N_F\lambda_I TZC_{IFMP} + \frac{N_F TZ}{T_{PM}}\ (MMH_{PM})$$

5.2.1.4 False Alarm Rate Considerations: The False Alarm Rate of FITS can contribute substantially to the cost of maintenance manpower, associated with any particular FITS design option. An assessment based on historical false alarm rate experience, or engineering judgement shall be made for each concept considered as a FITS option. The results of such an assessment shall be integrated into the cost, and maintenance manpower models provided that there exist significant differences in false alarm rates among design options.

5.3 Procedure for Synthesizing Detailed Design of the Selected FITS Concept: The procedure described herein represents a logical quantitative approach to the attainment of cost-effective design for the FITS, taking into account maintenance, maintainability, reliability and cost characteristics, and also provides support cost visibility throughout the design process. Other models may, however, be used subject to approval of the procuring activity.

5.3.1 Predesign Analyses Necessary: Analyses shall be performed to determine constraints relative to the characteristics of the FITS subsystem and its parts.

5.3.1.1 Determination of Design Constraints: Analyses shall be performed on the maintenance man-hours and the mean-time-to-repair requirement (in cases where only one of these maintainability figures of merit is used as a requirement the analysis shall be performed on it) to determine (X), the target maximum permissible number of LRUs* that may be isolated by a single set of diagnostics (when a group of two or more LRUs* are identified by a given set of diagnostics/test to contain the failed LRU*, final diagnosis must be made by semi-automatic or manual means which incur time costs). This value shall be used as a guide to define a target value(s) of (A). In order to accomplish this, the cost in terms of time and manpower required to isolate to a single LRU* (given that it is known that one LRU* of a group of LRUs* is failed) must be predicted, considering the relative failure frequencies and maintainability characteristics of the LRUs* in the group. A minimum failure detection probability shall be determined for those instances where design dictates separate and independent fault detections and isolation means. The analysis shall, in addition, determine a value for $(1-P_F)$, the minimum proportion of equipment (LRU*) failures sensitive to the equipment's FITS (i.e., at least 95% of all equipment faults shall be isolated to some minimum degree by the equipment's built-in-test capability) consistent with the requirements on mean-time-to-repair and maintenance man-hours. These shall be accomplished by consideration of the maintenance man-hours or mean-time-to-repair requirements, the costs and manpower required to diagnose an equipment fault in the event a failure was not identified by the FITS, the ramifications of not detecting a failure and the relative frequency of occurrence of such failures. The analysis rationale used for the above shall be subject to procuring activity review and approval.

5.3.1.2 Failure Modes and Effects Analysis: A Failure Modes and Effects Analysis shall be performed to determine the types and performance symptoms of failure inherent to the equipment design. This analysis shall be used to determine:

a. The types of fault detection means which are practical.

b. At what points isolation, to LRUs* or groups of LRUs*, can be implemented (through sets of diagnostic hardware or software).

c. The proportion of faults in each such LRU* or group of LRUs* detectable by the diagnostics in question.

5.3.1.3 Reliability and Maintainability: Reliability and maintainability analyses (predictions) shall be available down to the LRU* level.

5.3.1.4 Cost Information Relative to Fault Detection Implementation: An analysis to provide cost information relative to the implementation of each means of fault detection considered shall be prepared. The cost shall be expressed in terms of production cost, support man-hour cost, life cycle cost, or cost as defined by the procuring activity (see definition of C_{Ki} in paragraph 5.3.2.3).

5.3.2 Basis for the Design Procedure: This procedure is based on the concept that a cost-effective FIT subsystem should provide a greater degree of capability to isolate those failures which occur most frequently than those that occur less frequently. Further, it assumes that support costs (related to the ramifications of a given set of diagnostics) shall be considered during design. The basic premise for decision is the maximization of the proportion of equipment failures isolated per resource expended. An iterative procedure is used which, after any given amount of automatic diagnostics has been selected for the design, determines the most cost-effective next step and provides insight of the necessary characteristics for the ensuing diagnostic sets of hardware or software and is self terminating after the last design step.

5.3.2.1 <u>Information to be Provided</u>: The analyses described above shall provide the following information for guidance:

a. The target maximum number of LRUs*, (X), which can comprise a group of LRUs*, isolatable by a given set of diagnostics (for example, a set of diagnostics can indicate that the failed LRU is one of three particular LRUs).

b. The average proportion of failures in each LRU* or group of LRUs* isolatable by the diagnostics in question.

c. The reliability characteristics of each LRU*.

d. Information such that the cost of each set of diagnostics can be calculated.

5.3.2.2 <u>Determination of Alternatives</u>: In each iteration to provide a set of diagnostics (set i), the spectrum of practical possibilities shall be examined using a family of matrices. For example, in the specific case of LRUs each matrix in the family will present practical alternative diagnostics for all groups of LRUs which includes a specific LRU (LRU j), where LRU j is any LRU not considered in diagnostic sets selected in previous iterations. Hence, the family of matrices in the first iteration will include a matrix of all LRUs in the primary system and the number of matrices in the family will decrease with each iteration (see para. 5.3.3). The form of each matrix is as follows:

Combinations of LRUs including LRU j*	Alternatives for Set i of Diagnostics		
	Group Size	Proportion of Failures Detected	Cost
A	N_{Ai}	P_{oAi}	C_{Ai}
B	N_{Bi}	P_{oBi}	C_{Bi}
.	.	.	.
.	.	.	.
.	.	.	.
Z	N_{Zi}	P_{oZi}	C_{Zi}

*(Each combination (A, B, ...Z) contains from 1 to X LRUs including LRU j).

5.3.2.3 Explanation of Terms Used:

a. S = Total number of LRUs in equipment.

b. N_{Ki} = Total number of LRUs in group K of LRUs under consideration to be covered by the ith set of diagnostics (where group defines a collection of one or more LRUs where in the event of failure in one of the LRUs, isolation is made to the collection, rather than individual LRU).

c. λ_η = Failure rate of the ηth LRU.

d. X = Maximum number of LRUs contained in a group (determined from previous analyses).

e. P_K = A priori probability that a LRU in group K has failed, given an equipment failure (K = A, B, C, ...Z).

$$P_K = \frac{\sum_{\eta=1}^{N_{Ki}} \lambda_\eta}{\sum_{\eta=1}^{S} \lambda_\eta}$$

f. P_{oKi} = Proportion of faults in group K of LRUs under consideration to be identifiable by the ith set of diagnostics.

g. $(1-P_F)$ = Target value for proportion of faults in entire equipment identifiable by automatic diagnostics/isolation/test subystem (developed from analyses in paragraph 1.2).

$$\sum_{i=1}^{M} P_{oi}\, P_i = (1-P_F)$$

P_i = A priori probability that an LRU in the group covered by the ith set of diagnostics has failed, given an equipment failure.

P_{oi} = Proportion of faults in the group of LRUs identifiable by the ith set of diagnostics.

Where M = Estimated number of groups of LRUs (sets of diagnostics) in equipment.

h. C_{ki} = Cost of using group K of LRUs as the group of LRUs to be associated with the ith set of diagnostics. This can be expressed as:

(1) Hardware cost of implementing the ith set of diagnostics over and above that which has already been expended to implement the first (i-1) sets of diagnostics (the ith set of diagnostics might, for example, need a test circuit which has already been included in one of the other sets of diagnostics implemented. The cost of that circuit would not be included. C_{Ki} will also exclude costs associated with the use of existing circuitry, or software necessary for basic equipment operation and function).

(2) Cost in organizational maintenance manhours/year for diagnostics for that portion of a single system which FITS serves. In that case

$$C_{Ki} = \frac{P_K T_O}{MTBF}\left[P_{OKi}\,\overline{MMH}_{D/N_{Ki}} + (1-P_{OKi})\,\overline{MMH}_{D/S}\right]$$

where: T_O = Operational hours/year/prime system (equipment).

MTBF = Mean time between failure of prime system (equipment).

$\overline{MMH}_{D/N_{Ki}}$ = Average maintenance manhours to isolate (by semi-automatic or manual means) to the failed LRU, given failure is automatically isolated to a group of LRUs of siz N_{Ki}, by set of diagnostics/test, i.

$\overline{MMH}_{D/S}$ = Average maintenance manhours to isolate (by semi-automatic or manual means) to the failed LRU, given automatic diagnostics are inoperative or are incapable of isolation to a given group of LRUs.

(3) Cost in logistics and support resources necessary to the maintenance of the FITS itself.

(4) Any combination of the above (translated into dollars).

5.3.3 Procedure: Develop matrices of alternatives as discussed in para. 5.3.3.2 for the first diagnostic set. Consider all possible alternatives for the LRUs. For each determine the following numeric for i=1.

$$\frac{P_K P_{oKi}}{C_{Ki}} = \frac{\text{Proportion of faults isolated}}{\text{Resource Cost}}$$

Choose the alternative which maximizes this numeric. Develop new matrices for the second diagnostic set, not including combinations which contain any of the LRUs which comprised the group of LRUs diagnosable through diagnostic set 1. Repeat the above for the 2nd diagnostic set, i=2. Continue repeating for i=3, i=4....i=M, until all LRUs are divided into groups (equal to or less than X LRUs) covered by suitable diagnostics.

Recognizing that a final value of $(1-P_F)$ can result in a number of ways, the following provides guidance as to:

$\overline{P}_{oa/i}$ = Average proportion of faults detectable per remaining unformed groups of LRUs, which must be maintained or bettered in order to meet the P_F target.

$$\overline{P}_{oa/i} = \frac{1 - P_F - \sum_{i=1}^{K} P_i P_{oi}}{\dfrac{1 - \sum_{n=1}^{K} \lambda_n}{\lambda_{PE}}}$$

where: K = Total sets of diagnostics (groups of LRUs) implemented to date.

M = Estimated total sets of diagnostics (groups of LRUs) to be implemented in the equipment.

λ_{PE} = Failure rate of prime equipment which FITS serves.

Information relative to the above can serve to decrease the size of the matrices for the (K+1) diagnostic set by eliminating from consideration groups with values of P_{oKi} which are too large. It also serves to indicate if changes or modifications in plans and designs of diagnostic/isolation/test systems are required (for example, values of any P_{oi} may be increased or decreased with attendant cost changes).

The relationship

$$C_i = \frac{P_i T}{MTBF} \quad P_{oi} \overline{MMH}_{D/N_i} + (1-P_{oi}) \overline{MMH}_{D/S}$$

provides step-by-step visibility of the manpower cost attributable to that particular diagnostic set characteristic.

Where: C_i = Operational manpower cost attributable to the ith set of diagnostics.

$\overline{MMH}_{D/N_i}$ = Average maintenance man-hours to isolate (by semi-automatic or manual means) to the failed LRU, given failure is automatically isolated to a group of LRUs of size N_i by set of diagnostics/test i.

$\overline{MMH}_{D/S}$ = Average maintenance man-hours to isolate (by semi-automatic or manual means) to the failed LRU, given automatic diagnostics/test are inoperative or are incapable of isolation to a given group of LRUs.

VI. RADC PUBLICATIONS

The following RADC publications are suggested for use as guidance to determine the optimal design for a Command and Control System/Component Fault Diagnosis/Isolation System (see Section 2):

RADC-TR-69-140, Test Instrumentation Requirements and Techniques for Advanced Systems.

RADC-TR-71-281, Design of Integral Sensor Test System.

RADC-TR-74-308, Maintainability Engineering Design Notebook, Revision II, and Cost of Maintainability.

VII. DATA

Plans for performing the analyses described herein shall be outlined in the Maintainability Program Plan as specified in MIL-STD-470 (ESD amended version). The results of the analysis/synthesis shall be documented as appropriate in DOD DI-S-3605.

Reviewer - 13

Preparing Activity
Air Force - 17

Project MISC - FD13

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

OMB Approval No. 22-R255

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