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BIT/EXTERNAL TEST FIGURES OF MERIT AND DEMONSTRATION TECHNIQUES

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Current maintainability parameters and corresponding analysis/demonstration techniques lack the capability of expressing the adequacy of Built-in-Test and/or External Test Equipment (BIT/ETE). Figures of Merit (FOMs) have been identified and defined that can be used to express the adequacy of BIT/ETE. Methodologies have been developed to analyze and demonstrate the defined BIT/ETE FOMs. A methodology has also been developed to methodically select the BIT/ETE FOMs required in system/equipment specifications based on the desired system/equipment objectives and requirements.

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0.0 SUMMARY

Due to the increase in the use of Built-In Test (BIT) and External Test Equipment (ETE), for maintainability purposes, in recent years the figures of merit (FOM), analyses techniques and demonstration techniques currently used for maintainability lack the capability of expressing the adequacy of BIT and/or ETE (BIT/ETE). The objective of this study was to determine what BIT/ETE FOMs and their associated analysis/demonstration techniques are required to determine the adequacy of BIT/ETE. Also, how and when should these BIT/ETE FOMs be specified.

The BIT/ETE FOMs defined and examined in this study have all appeared in previous system/equipment specifications. However, few system specifications have thoroughly defined all the BIT/ETE objectives and in many cases the interpretation of the requirements was ambiguous. As a result of this study a firm definition of each of the BIT/ETE FOMs has been established. These definitions and the models that define them are summarized in Table 1. For the FOMs defined with "detected faults", "detectable faults" can be interchanged with "detected faults" without affecting the definition of the FOM. For each of the defined BIT/ETE FOMs, methodologies have been developed for analysis and demonstration. The analysis and demonstration techniques developed consist of existing techniques, modification of existing techniques, and new techniques. Table 2 summarizes the various analysis and demonstration techniques that apply to each BIT/ETE FOM.

A methodology has also been developed to determine when each BIT/ETE FOM should be specified. The methodology correlates the various system/equipment BIT/ETE objectives with the BIT/ETE FOMs that suit each objective the best. Determination of the most suitable FOMs was based on 1) how the BIT/ETE FOM was related to BIT/ETE objective, and 2) how well the BIT/ETE FOM was evaluated as a figure of merit. Guidelines have also been provided to ensure that the specification of numerical values for multiple FOMs (i.e., when specifying related FOMs together) is consistent (i.e., not contradictory).

The final result of this study indicates that only minor alterations are required to integrate BIT/ETE FOMs defined and their corresponding analysis/demonstration techniques into the present maintainability program plans. The minor alterations that are required have been developed in this report.

TABLE 1. SUMMARY OF DEFINITIONS

#	Figure of Merit	Definition	General Model
1	Fraction of Faults Detected (FFD)	a) the fraction of all faults detected (or detectable) by BIT/ETE. b) the fraction of all detectable faults detected (or detectable) with BIT/ETE.	$FFD_A = \frac{\text{quantity of faults detected by BIT/ETE } (Q_{BDF})}{\text{quantity of all faults } (Q_F)}$ $FFD_D = \frac{\text{quantity of faults detected by BIT/ETE } (Q_{BDF})}{\text{quantity of faults detected } (Q_{FD})}$
2	Fraction of False Alarms (FFA)	the fraction of all BIT/ETE indicated faults which are false alarms. False Alarms are those indications of a fault when an actual fault has not occurred.	$FFA = \frac{\text{quantity of BIT/ETE false alarms } (Q_{FA})}{\text{quantity of all BIT/ETE indicated faults } (Q_{BIF})}$
3	Fraction of False Status Indications (FFSI)	The fraction of BIT/ETE fault indications (or lack thereof) which are erroneous.	$FFSI = \frac{\{\text{quantity of false alarms } (Q_{FA})\} + \{\text{quantity of undetected faults } (Q_{UD})\}}{\{\text{quantity of BIT/ETE indicated faults } (Q_{BIF})\} + \{\text{quantity of undetected faults } (Q_{UD})\}}$
4	Mean Fault Detection Time (T_{FD})	The average time it takes for BIT/ETE function to detect and indicate a fault from the time the fault has occurred.	$T_{FD} = \frac{\sum_{i=1}^{Q_{BDF}} (\text{time to detect and indicate the } i^{th} \text{ BIT/ETE detectable fault})}{Q_{BDF}}$
5	Mean BIT/ETE Running Time (T_B)	The average active time to perform a BIT/ETE routine. This can be the average for one test, a group of tests, or all tests.	$T_B = \frac{\sum_{i=1}^{NB} (\text{active running time of the } i^{th} \text{ BIT/ETE test routine, } T_{B_i})}{\text{the number of BIT/ETE test routines } (N_B)}$
6	Frequency of BIT/ETE Executions (F_L)	The frequency (or cycling rate) at which periodic BIT/ETE tests are executed (This does not apply to BIT/ETE tests that are executed only upon requests).	$F_B = \left\{ \begin{array}{l} \text{[the time it takes to execute the complete set of BIT/ETE test routines]} \\ + \text{[the idle time between the execution of the complete set of BIT/ETE test routines]} \end{array} \right\}^{-1}$
7	Test Thoroughness (TT)	The fraction of the equipment/system tested by BIT/ETE relative to the entire equipment/system.	$TT = \frac{\text{(amount of system/equipment tested by BIT/ETE)}}{\text{(amount of system/equipment tested by BIT/ΣTE)} + \text{(amount of system equipment not tested by BIT/ETE)}}$
8	Fault Isolation Resolution (FIR(L))	The fraction of detected faults isolated by BIT/ETE down to an acceptable (specified) minimum number of replaceable items.	$FIR(L) = \frac{\text{quantity of detected faults isolatable to} \le \text{L RIs with BIT/ETE } (Q_{IL})}{\text{quantity of detected faults } (Q_{FD})}$
9	Fraction of Faults Isolated (FFI)	The fraction of faults detected by BIT/ETE, isolated with BIT/ETE to the replacement level specified by the maintenance concept.	$FFI = \frac{\text{quantity of detected faults isolated with BIT/ETE } (Q_{IB})}{\text{quantity of faults detected } (Q_{FD})}$
10	Mean Fault Isolation Time (T_{FI})	The average time to complete the fault isolation process using BIT/ETE.	$T_{FI} = \frac{\sum_{i=1}^{Q_{BDF}} (\text{time to isolate the } i^{th} \text{ fault with BIT/ETE})}{Q_{BDF}}$
11	Maintenance Personnel Skill Level (MPSL)	a) the average skill level required to perform corrective maintenance for a system/equipment b) the minimum skill level required to perform corrective maintenance on a system/equipment	Not Applicable
12	BIT/ETE Reliability ($MTBF_{B/E}$)	The probability that the BIT/ETE circuitry will perform its intended function for a specified interval under specified conditions. BIT/ETE circuitry is any hardware that is used for BIT/ETE testing that is not common to the system hardware.	$MTBF_{B/E} = [\lambda_{B/E}]^{-1} = \left\{ \sum_{i=1}^{N_{B/E}} \lambda_{B/E_k} \right\}^{-1}$ $N_{B/E}$ = quantity of BIT/ETE hardware components not common to system hardware
13	BIT/ETE Maintainability ($MTTR_{B/E}$)	The average time to repair a fault in the BIT/ETE hardware.	$N_{B/E}$

8	Fault Isolation Resolution (FIR(L))	The fraction of detected faults isolated by BIT/ETE down to an acceptable (specified) minimum number of replaceable items.	$FIR(L) = \frac{\text{quantity of detected faults isolatable to} \le L \text{ RIs with BIT/ETE } (Q_{IL})}{\text{quantity of detected faults } (Q_{FD})}$
9	Fraction of Faults Isolated (FFI)	The fraction of faults detected by BIT/ETE, isolated with BIT/ETE to the replacement level specified by the maintenance concept.	$FFI = \frac{\text{quantity of detected faults isolated with BIT/ETE } (Q_{IB})}{\text{quantity of faults detected } (Q_{FD})}$
10	Mean Fault Isolation Time (T_{FI})	The average time to complete the fault isolation process using BIT/ETE.	$T_{FI} = \frac{\sum_{i=1}^{Q_{BDF}} (\text{time to isolate the } i^{th} \text{ fault with BIT/ETE})}{Q_{BDF}}$
11	Maintenance Personnel Skill Level (MPSL)	a) the average skill level required to perform corrective maintenance for a system/equipment b) the minimum skill level required to perform corrective maintenance on a system/equipment	Not Applicable
12	BIT/ETE Reliability ($MTBF_{B/E}$)	The probability that the BIT/ETE circuitry will perform its intended function for a specified interval under specified conditions. BIT/ETE circuitry is any hardware that is used for BIT/ETE testing that is not common to the system hardware.	$MTBF_{B/E} = [\lambda_{B/E}]^{-1} = \left\{ \sum_{k=1}^{N_{B/E}} \lambda_{B/E_k} \right\}^{-1}$ $N_{B/E}$ = quantity of BIT/ETE hardware components not common to system hardware
13	BIT/ETE Maintainability ($MTTR_{B/E}$)	The average time to repair a fault in the BIT/ETE hardware.	$MTTR_{B/E} = \frac{\sum_{k=1}^{N_{B/E}} \lambda_{B/E_k} M_{CT\,k}}{\sum_{k=1}^{N_{B/E}} \lambda_{B/E\,k}}$
14	BIT/ETE Availability ($A_{B/E}$)	A measure of the degree to which the BIT/ETE circuitry is in the operable and committable state at the start of a mission, when the mission is called for at an unknown (random) point in time.	$A_{B/E} = \frac{MTBF_{B/E}}{MTBF_{B/E} + MTTR_{B/E}}$
15	System Maintainability (MTTR)	The average corrective maintenance time for all system/equipment faults.	$MTTR = \frac{\sum_{i=1}^{N} \lambda_i M_{ct_i}}{\sum_{i=1}^{N} \lambda_i}$
16	System Availability (A)	A measure of the degree to which a system/equipment is in the operable and committable state at the start of a mission, when the mission is called for at an unknown (random) point in time.	$A = \frac{MTBF}{MTBF + MTTR}$
17	Fraction of False Pulls (FFP)	The fraction of RIs removed from a system, due to the result of a BIT/ETE fault isolation process, that are good RIs (i.e., RIs with no actual failure within it).	$FFP = \frac{\text{quantity of good RIs removed } (Q_{GRI})}{\text{quantity of RIs removed } (Q_{RR})}$
18	Fraction of Erroneous Fault Isolation Results (FEFI)	The fraction of BIT/ETE fault isolation results that identify the wrong RI once a fault has been detected.	$FEFI = \frac{\text{quantity of erroneous fault isolation results. } (Q_{EFIR})}{\text{quantity of fault isolation results. } (Q_{FIR})}$

TABLE 2. SUMMARY OF BIT/ETE FOM ANALYSIS/DEMONSTRATION TE

BIT/ETE FOM	Analysis Technique	Demonstration Technique
• Fraction of Faults Detected (FFD)	• can be analyzed by a ratio of occurrence rates (e.g., failure rate)	• can be verified by a binominal dist by field data collection (FFD_D only)
• Fraction of False Alarms (FFA)	• can be analyzed by a ratio of occurrence rates (e.g., failure rate)	• can be verified by field data collect
• Fraction of False Status Indications (FFSI)	• can be analyzed by a ratio of occurrence rates (e.g., failure rate)	• can be verified by field data collect
• Mean Fault Detection Time (T_{FD})	• can be analyzed by a method similar to MIL-HDBK-472 procedure 2 or RADC-TR-78-169, a failure rate weighted average of times (times determined thru time line analysis)	• can be verified by direct time meas
• Mean BIT/ETE Running Time (T_B)	• can be analyzed by time line analysis since there is no randomness in its occurrence	• can be verified by direct time meas
• Frequency of BIT/ETE Executions (F_B)	• can be analyzed by time line analysis since there is no randomness in its occurrence	• can be verified by direct time meas
• Test Thoroughness (TT)	• can be analyzed by a ratio of occurrence rates (e.g., failure rate)	• can be verified by direct measurem the same way FFD is demonstrated, on how it is defined
• Fault Isolation Resolution (FIR(L))	• can be analyzed by a ratio of occurrence rates (e.g., failure rate)	• can be verified by a multinomial di or by field data collection
• Fraction of Faults Isolated (FFI)	• can be analyzed by a ratio of occurrence rates (e.g., failure rate)	• can be verified by a binomial distri by field data collection
• Mean Fault Isolation Time (T_{FI})	• can be analyzed by a method similar to MIL-HDBK-472, procedure 2 or RADC-TR-78-169, a failure rate weighted average of times (times determined thru time line analysis)	• can be verified by techniques simil MIL-STD-471 or by field data colle
• Maintenance Personnel Skill Level (MPSL)	• can be analyzed by a weighted average of skill levels if it is defined as an average, otherwise it is strictly determined by measuring the maximum skill level required for each maintenance action	• can be verified by direct measurem field data collection
• BIT/ETE Reliability ($MTBF_{B/E}$)	• can be analyzed using MIL-HDBK-217	• can be verified by using the techni MIL-STD-781 or field data collection
• BIT/ETE Maintainability ($MTTR_{B/E}$)	• can be analyzed using MIL-HDBK-472, RADC-TR-78-169	• can be verified using the technique MIL-STD-471 or field data collection
• BIT/ETE Availability ($A_{B/E}$)	• can be analyzed using current techniques to determine reliability and maintainability (e.g., MIL-HDBK-217, MIL-HDBK-472, etc...)	• can be verified by using the techni MIL-STD-781 and MIL-STD-471 or b collection
• System Maintainability (MTTR)	• can be analyzed using MIL-HDBK-472, RADC-TR-78-169.	• can be verified by using the techni MIL-STD-471 or field data collection
• System Availability (A)	• can be analyzed using current techniques to determine reliability and maintainability (e.g., MIL-HDBK-217, MIL-HDBK-472, etc...)	• can be verified by using the techni MIL-STD-781 and MIL-STD-472 or b data collection
• Fraction of Erroneous Fault Isolation Results (FEFI)	• can not be analyzed	• can be verified by a binomial distri by field data collection

TABLE 2. SUMMARY OF BIT/ETE FOM ANALYSIS/DEMONSTRATION TECHNIQUES

FOM	Analysis Technique	Demonstration Technique
ts Detected (FFD)	• can be analyzed by a ratio of occurrence rates (e.g., failure rate)	• can be verified by a binominal distribution or by field data collection (FFD_D only)
Alarms (FFA)	• can be analyzed by a ratio of occurrence rates (e.g., failure rate)	• can be verified by field data collection only
Status Indications	• can be analyzed by a ratio of occurrence rates (e.g., failure rate)	• can be verified by field data collection only
tion Time (T_{FD})	• can be analyzed by a method similar to MIL-HDBK-472 procedure 2 or RADC-TR-78-169, a failure rate weighted average of times (times determined thru time line analysis)	• can be verified by direct time measurement
nning Time (T_B)	• can be analyzed by time line analysis since there is no randomness in its occurrence	• can be verified by direct time measurement
/ETE Executions	• can be analyzed by time line analysis since there is no randomness in its occurrence	• can be verified by direct time measurement
s (TT)	• can be analyzed by a ratio of occurrence rates (e.g., failure rate)	• can be verified by direct measurement or the same way FFD is demonstrated, depending on how it is defined
solution (FIR(L))	• can be analyzed by a ratio of occurrence rates (e.g., failure rate)	• can be verified by a multinomial distribution or by field data collection
s Isolated (FFI)	• can be analyzed by a ratio of occurrence rates (e.g., failure rate)	• can be verified by a binomial distribution or by field data collection
ion Time (T_{FI})	• can be analyzed by a method similar to MIL-HDBK-472, procedure 2 or RADC-TR-78-169, a failure rate weighted average of times (times determined thru time line analysis)	• can be verified by techniques similar to MIL-STD-471 or by field data collection
onnel Skill Level	• can be analyzed by a weighted average of skill levels if it is defined as an average, otherwise it is strictly determined by measuring the maximum skill level required for each maintenance action	• can be verified by direct measurement or by field data collection
ity ($MTBF_{B/E}$)	• can be analyzed using MIL-HDBK-217	• can be verified by using the techniques of MIL-STD-781 or field data collection
ability	• can be analyzed using MIL-HDBK-472, RADC-TR-78-169	• can be verified using the techniques of MIL-STD-471 or field data collection
lity ($A_{B/E}$)	• can be analyzed using current techniques to determine reliability and maintainability (e.g., MIL-HDBK-217, MIL-HDBK-472, etc...)	• can be verified by using the techniques of MIL-STD-781 and MIL-STD-471 or by field data collection
lity (MTTR)	• can be analyzed using MIL-HDBK-472, RADC-TR-78-169	• can be verified by using the techniques of MIL-STD-471 or field data collection
(A)	• can be analyzed using current techniques to determine reliability and maintainability (e.g., MIL-HDBK-217, MIL-HDBK-472, etc...)	• can be verified by using the techniques of MIL-STD-781 and MIL-STD-472 or by field data collection
ous Fault (FEFI)	• can not be analyzed	• can be verified by a binomial distribution or by field data collection

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EVALUATION

The objective of this study was to investigate and determine figures of merit that could be used in specifications as requirements for Built-in-Test (BIT) and external tester adequacy as well as the corresponding demonstration techniques and procedures that could be used to verify that the figures of merit have been achieved.

The objectives have been satisfactorily fulfilled. The final report provides the information necessary to adequately specify, analyze, and demonstrate the BIT/ETE capabilities contained in a system/equipment. The methodologies presented are compatible with existing maintainability program elements and allow BIT/ETE requirements to be easily integrated into standard maintainability programs.

The use of the results of this effort provides the foundation for the consistent specification and verification of effective BIT/ETE figures of merit in electronic equipment/system acquisitions.

JERRY F. LIPA, JR.
Project Engineer

1.0 INTRODUCTION

This document presents the results of a study to investigate and determine the measures and figures of merit that should be used in specifications as requirements for Built-in Test (BIT) and External Test Equipment (ETE) adequacy. This study was performed under Contract F30602-78-C-0137 with Rome Air Development Center. This report is prepared in accordance with CDRL Item A002 and data item description DI-S-3591A/M.

1.1 DEFINITION OF THE PROBLEM

In recent years the use of Built-in Test (BIT) and/or External Test Equipment (ETE) as maintenance tools has increased significantly. For purposes of this study BIT and ETE are defined as:

<u>Built-In Test (BIT)</u> – That capability internal to an equipment/system which is provided for the purpose of failure detection and/or isolation. Includes built-in test equipment (BITE), software programs, firmware programs, test circuitry, maintenance panels, status indicators, etc.

<u>External-Test-Equipment (ETE)</u> – That special purpose or general purpose test equipment external to an equipment/system which is designated for use in the failure detection and/or isolation process.

The figures of merit, analysis techniques, and demonstration techniques that are currently used for the purpose of maintainability lack the capability of expressing the adequacy of BIT and/or ETE (BIT/ETE) within a system/equipment. The objective of this study was to determine the measures and figures of merit that are required to determine BIT/ETE adequacy. Furthermore, methodologies were to be developed to analyze and demonstrate these measures. Specific objectives included:

1) survey current figures of merit to determine their usefulness and completeness for BIT/ETE specification and determine other figures of merit required, appropriate to BIT/ETE specification.
2) determine methods of measurement and demonstration for the associated figures of merit.
3) provide guidance for the specification of appropriate figures of merits and their numerical values in maintainability requirements.
4) provide guidance pertaining to the integration of BIT/ETE requirements and analysis/demonstration techniques into the current maintainability program plans.

1.2 APPROACH

The approach to satisfying the study objectives consisted of the following:

1) Data collection – This task consisted of surveying the BIT/ETE FOMs that are currently used and identifying what methodologies exist for analyzing and demonstrating those FOMs. The outcome of this task was used to aid in the identification of additional BIT/ETE FOMs or analysis/demonstration methodologies required.

2) FOM evaluation – This task consisted of evaluating the suitability of the defined FOMs as design specifications. A weighted rating evaluation approach was used.

3) Analysis/demonstration techniques development – This step consisted of developing appropriate analysis and demonstration techniques for the defined FOMs. The resulting techniques are a combination of existing, modified and new methodologies.

4) FOM specification guidelines – This task consisted of developing a procedure for determining what BIT/ETE FOMs should be specified for given system/equipment objectives.

5) Integration of BIT/ETE FOMs into maintainability programs – This task consisted of determining how the newly developed BIT/ETE FOMs and their associated analysis/demonstration techniques should be implemented into a maintainability program plan.

2.0 DATA COLLECTION

2.1 OBJECTIVE/APPROACH

A data collection effort was undertaken to determine what BIT/ETE FOMs are currently being used, what current methodologies are being used for analyzing and testing BIT/ETE, what are the accepted quantitative and qualitative definitions for typical BIT/ETE FOMs, and what inherent fault detection or fault isolation characteristics are not adequately covered by the current BIT/ETE FOMs. The data collection effort consisted of three separate tasks:

1. literature search,
2. system specifications search, and
3. industry survey

The following subsections summarize the approach and findings of each data collection task.

2.2 LITERATURE SEARCH

The first task performed in the data collection effort was an extensive literature search. The literature search consisted of two different efforts; 1) survey of military standards and handbooks for current BIT/ETE requirements and definitions and, 2) survey of technical publications related to BIT/ETE.

2.2.1 Specification Review

Table 3 is a list of the documents examined that relate to BIT/ETE requirements. Investigation of the table indicates that a majority of the specifications reference MIL-STD-415 when specifying requirements on BIT/ETE. MIL-STD-415, paragraph 5.2.3, which is reproduced in Figure 1, only contains qualitative requirements on BIT/ETE. The only specification that contained any quantitative requirements on BIT/ETE was NAVAIR AR-10. NAVAIR AR-10 contained specific requirements on the proportion of faults detected/isolated by BIT/ETE, and the fault isolation ambiguity level. However, NAVAIR AR-10 is only applicable to NAVAIR avionic equipment.

The only other document that contains information on the specification of BIT/ETE requirements is NAVMAT-3960. NAVMAT 3960 provides guidelines for the design and specification of BIT/ETE, but does not attempt to relate these requirements to quantitative FOMs. The FOMs which are discussed include:

- Availability
- Reliability
- Mean Corrective Maintenance Time
- Fault Definition
- BIT Detectability Level
- BIT Fault-Isolation Level
- BIT False-Alarm Rate
- BIT Self-Test Requirement
- Extent of Operator Participation
- Software Constraints (memory capacity)
- Design Growth Limits
- Design Cost Goal (contract specification)
- BIT Fail-Safe Provisions
- Fault Indicators
- Special BIT Features
- BIT Calibration Requirements

TABLE 3. SUMMARY OF BIT/ETE REQUIREMENTS CURRENTLY SPECIFIED IN MILITARY STANDARDS

Document Number	Document Description	References to BIT/ETE Requirements	
		Paragraph Number	Paragraph Description
MIL-STD-454	Standard General Requirements for Electronic Equipment	requirement 32	references MIL-STD-415
MIL-STD-415	Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for	5.2.3	Qualitative requirements on BIT capability
MIL-E-5400	Electronic Equipment, Airborne, General Specification for	Appendix	References MIL-STD-415
MIL-E-16400	Electronic, Interior Communication and Navigation Equipment, Naval Ship & Shore: General Specification for	3.6.1	References MIL-STD-454
NAVAIR AR-10	Maintainability of Avionics Equipment and Systems, General Requirements for	3.3.3 3.4.3.2	Quantitative requirements on the percent of faults detected/isolated by BIT Quantitative requirements on the fault isolation ambiguity level
MIL-STD-471*	Maintainability Verification/Demonstration/Evaluation	Appendix C	Methodology for evaluating BIT/ETE fault isolation and testability attributes
NAVMAT-3960	BIT Design Guide	5.1 5.2 5.3	References MIL-STD-415 Recommended BIT parameters (FOMs) Recommended BIT specifications (general)
MIL-STD-1591	On-Aircraft, Fault Diagnosis, Subsystems, Analysis of	All	Methodology for determining the most cost effective BIT/ETE design

*Proposed addendum to MIL-STD-471

5.2.3 BIT capability. – The built-in-test (BIT) capability shall be incorporated as required by the contract to assure effective implementation of the defined maintenance concept. The built-in-test capability shall consist of the following:

(a) Self-test provisions: Self-test provisions shall be an inherent part of an item. These provisions shall serve a dual function: item performance evaluation, and complementing BIT provisions to provide item testing. When self-test provisions are practical, the contractor shall use them; however, their use shall not jeopardize the operation or performance of the item.

(b) Marginal testing: When critical item parameters or characteristics are subject to change or drift and BIT capabilities must be used, these areas shall be tested by marginal testing techniques as defined in this standard.

5.2.3.1 Applicability of test provision classes. – Class A and B test provisions shall be applicable to the BIT capability.

5.2.3.2 BIT provisions. – BIT provisions shall be added to an item for the sole purpose of testing the item. They shall be simple in design and operation, accurate, easily maintained, preferably more reliable than the circuitry providing performance, and shall not degrade the performance of the item in which they are incorporated.

5.2.3.3 Ease of operation. – BIT provisions shall provide optimum convenience of use and operation. The design of controls and read-out devices shall be such that they can be easily used and interpreted by low skill personnel. To the maximum extent it shall be possible to operate the provisions with minimum reference to item handbooks. The need for external equipment or tools to supplement this testing capability shall be minimized.

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Figure 1. BIT/ETE Requirements of MIL-STD-415

2.2.2 Technical Publications Review

Sources for the technical publications literature search were:

1. Defense Documentation Center (DDC)
2. NASA Scientific and Technical Information Division
3. Hughes Aircraft Technical Library

A majority of the publications reviewed dealt with the design of BIT/ETE, but did not address BIT/ETE specification, analysis, or demonstration. The only document that contained any information about the specification of BIT/ETE was A Guide to the Application of Built-in Test to Navy Avionic Equipment, by ARINC Research Corporation (AD 837 694). One section was devoted to the specification of BIT/ETE, however, the content of that section merely stressed the need for better ways to specify BIT/ETE. It also gave relative guidelines on what the specifications should be capable of (i.e., BIT/ETE specifications should be capable of demonstration).

2.3 SYSTEM SPECIFICATION SURVEY

The second data collection task used to identify the BIT/ETE FOMs that are currently in use was to survey a representative sample of system specifications. The review included specifications for forty-nine systems in which Hughes has been either the contractor for, or a candidate contractor for. These forty-nine system specifications cover a broad range of environments with 11 airborne, 16 ground, 18 shipboard, 4 missile, and 1 space (one system is used in ground and airborne environments).

A review of the composite collection of FOMs identified in the system specification review indicates that all the FOMs fall into seventeen generic groupings. The specific FOMs within each group vary in numerical value and exact definition but all relate to the same generic fault detection and/or fault isolation characteristic. The general BIT/ETE FOMs identified and their various forms encountered were:

1) <u>fraction of faults detected:</u>
   - percent of all faults automatically detected by BIT/ETE
   - percent of all faults detectable by BIT/ETE
   - percent of all faults detectable on-line by BIT/ETE
   - percent of all faults and out-of-tolerance conditions detectable by BIT/ETE
   - percent of all faults detectable by any means
2) <u>fraction of false alarms</u>
   - rate at which false indications occur (per 10^6 hours)
   - percent of indicated failures caused by actual failures
   - percent of BIT/ETE indicated failures caused by actual failures
   - percent of BIT/ETE fault isolations to the wrong LRU
3) <u>fraction of false status indications</u>
   - percent of erroneous BIT indications
4) <u>mean fault detection time</u>
   - time to indicate a fault once it has occurred
   - time to detect a fault once it has occurred
5) <u>mean BIT/ETE running time</u>
   - time to verify that a failure has occurred/or has been repaired using BIT/ETE
6) <u>frequency of BIT/ETE executions</u>
   - time interval between BIT/ETE executions

7) test thoroughness

- percent of all equipment functions tested

8) fault isolation resolution

- isolation of P_1 percent of the failures to X_1 LRUs, P_2 percent of the failures to X_2 LRUs and so on, with any fault isolation method.
- isolation of all faults to less than or equal to some maximum number of LRUs.
- isolation of P_1 percent of the failures to X_1 LRUs, P_2 percent of the failures to X_2 LRUs, and so on, with BIT/ETE
- isolation of a specified percent of the failures to less than or equal to a specified quantity of LRUs at the various maintenance levels.
- isolation of a specified percent of the failures down to less than or equal to a maximum number of plug-in modules.
- isolation semi-automatically to a certain percent of all faults down to a specified number of LRUs.

9) fraction of faults isolated

- isolate a certain percent of all failures that occur
- isolate a certain percent of all failures that occur with BIT/ETE

10) mean fault isolation time

- isolate a specified percent of failures that occur within a specified maximum time.
- isolate a failure down to a replaceable level, within a specified average time.
- isolate a failure down to a replaceable level within a specified time once the fault isolation process has been initiated.

11) maintenance personnel skill level

- all maintenance actions must be capable of being performed by a specified quantity of maintenance personnel with a specified skill level, at various maintenance levels.
- BIT/ETE must be designed for use by a specified minimum skill level technician

12) BIT/ETE mean-time-to-repair

- mean-time-to-repair ETE
- mean-time-to-repair monitoring/fault isolation functions

13) <u>BIT/ETE mean time between failures</u>

- mean time between failures of monitoring/fault isolation functions
- mean time between failures of ETE only

14) <u>BIT/ETE availability</u>

- monitoring/fault isolation functions should be operating with a specified probability of survival.

15) <u>mean-time-to-repair</u>

- system/equipment MTTR & maximum repair time
- system/equipment MTTR & maximum repair time at various maintenance levels

16) <u>availability</u>

- inherent availability
- operational availability

17) <u>active memory allocated for BIT/ETE functions</u>

- monitoring/fault isolation functions shall take up a specified percent of active computer memory.

A summary of the system specifications reviewed and BIT/ETE FOMs identified in each is shown in Table 4.

TABLE 4. SUMMARY OF BIT/ETE FOMs SPECIFIED IN SYSTEM REQUIREMENTS

SYSTEM/EQUIPMENT	GENERIC BIT/ETE FOM TYPES: fraction of faults detected	fraction of false alarms	fraction of false status indications	mean fault detection time	mean BIT/ETE running time	frequency of BIT/ETE executions	test thoroughness	fault isolation resolution	fraction of faults isolated	mean fault isolation time	maintenance personnel skill level	BIT/ETE MTTR	BIT/ETE MTBF	BIT/ETE availability	MTTR	availability	memory allocation for BIT/ETE	MTBF
AIRBORNE:																		
1. JTIDS FSD	X		X					X	X		X				X	X		X
2. TDMA-A	X							X			X				X			X
3. TDMA-B	X							X			X				X			X
4. HIT	X							X			X				X			X
5. F-16 RADAR	X	X		X	X	X			X	X		X	X		X			X
6. APG-63	X	X		X			X		X	X					X			X
7. FLIR										X					X			X
8. IWDS								X							X	X		X
9. TOSS II	X	X		X			X	X							X			X
10. GBU-15																		X
11. THORNTON*															X			X
GROUND:																		
1. SEEK IGLOO	X	X		X				X	X		X	X	X	X	X	X		X
2. PLRS															X	X		X
3. COMBAT GRANDE	X							X			X				X	X		X
4. AN/TPQ-36															X			X
5. AN/TPQ-37															X			X
6. JSS				X											X	X		X
7. AN/PRC-104															X			X
8. RADEX						X									X	X		X
9. MIFASS											X				X	X	X	X
10. HADR															X	X		X
11. FIREFINDER				X				X			X				X			X
12. XM-1								X	X	X	X				X			X
13. M60A2																		X
14. M60A3																		X
15. SHERIDAN LRF																		X

* also used in ground environment

TABLE 4. SUMMARY OF BIT/ETE FOMs SPECIFIED IN SYSTEM REQUIREMENTS (Continued)

SYSTEM/EQUIPMENT	GENERIC BIT/ETE FOM TYPES																	
	fraction of faults detected	fraction of false alarms	fraction of false status indications	mean fault detection time	mean BIT/ETE running time	frequency of BIT/ETE executions	test thoroughness	fault isolation resolution	fraction of faults isolated	mean fault isolation time	maintenance personnel skill level	BIT/ETE MTTR	BIT/ETE MTBF	BIT/ETE availability	MTTR	availability	memory allocation for BIT/ETE	MTBF
Shipboard																		
1. MK-113															X	X		X
2. MK-82								X							X			X
3. SID								X		X	X				X			X
4. AN/SPS-52															X			X
5. BQQ-5	X								X						X			X
6. BQQ-6	X								X						X			X
7. AN/SLQ-31										X						X		
8. AN/SLQ-17															X			X
9. AN/SSQ-78											X				X			X
10. SURTASS	X			X				X			X				X	X		X
11. UYA-4															X			X
12. MK-117								X							X			X
13. TUNA SID															X			X
14. SSURADS																X		
15. AN/UYQ-21								X							X			X
16. SADS																X		
17. TDCC	X							X							X			X
18. IPD/TAS								X			X		X			X		X
MISSILE:																		
1. MAVERICK															X			X
2. PHOENIX	X							X							X			X
3. TOW											X				X			X
4. ROLAND															X	X		X
SPACE:																		
1. SIRE																		X

2.4 INDUSTRY SURVEY

The third task of the data collection effort was an industry survey. The objective of this task was to broaden the data base obtained through the literature search, and the system specification survey, by surveying reliability/maintainability engineers from companies that are familiar with the use of RMA techniques and the specification/test of BIT/ETE requirements in DoD contracts.

A list of candidate companies was extracted from the list of Government Industry Data Exchange Program (GIDEP) subscribers. A BIT/ETE survey questionnaire was submitted to the reliability/maintainability engineers of each respective company. Figure 2 is a copy of the questionnaire form submitted. The questionnaire was set up to collect the following information:

1) BIT/ETE FOMs that are currently used and type of system they are used on
2) recommendations for new BIT/ETE FOMs
3) user critique of the BIT/ETE FOMs identified.

Of the one hundred thirty-nine questionnaires sent out, thirty-one responses were received, for a 22 percent return. Of the thirty-one responses received, twenty-eight responses contained usable data. The remaining responses were blank.

Part I of the BIT/ETE questionnaire (Figure 2) was used to identify what BIT/ETE FOMs each respective engineer has had experience with (either in analysis, demonstration, or specification) and the types of equipments (e.g., shipboard, ground, airborne, etc...) they have been used on. In order to aid the engineers that were polled, the BIT/ETE FOMs identified to date were tabulated for their convenience. Space was provided for additional FOMs. The results of this part of the survey indicate that the BIT/ETE FOMs listed are FOMs that have been encountered in one way or another (i.e., in specification, analysis, or demonstration) for the various system types. The results also showed, as expected, the lack of experience in demonstrating several of the BIT/ETE FOMs tabulated such as; false alarm rate/false status indications, fault isolation ambiguity level, and percent of fault isolation with BIT/ETE.

Part II of the BIT/ETE questionnaire (Figure 2) was used to obtain each engineer's view of the usefulness of the BIT/ETE FOMs identified. This part of the questionnaire consisted of a scoring checklist to rate each FOM according to the following suitability factors: translatability, trackability, demonstrability, 92729-10

BIT/ETE SURVEY QUESTIONAIRE — PART I

FIGURES OF MERIT	FIGURE OF MERIT APPLICATIONS: SPECIFIED? YES	SPECIFIED? NO	ANALYZED? YES	ANALYZED? NO	DEMONSTRATED? YES	DEMONSTRATED? NO	EQUIPMENT TYPE: AVIONICS	MISSILES	GROUND ELECTRONICS	SHIPBOARD ELECTRONICS	OTHER:
PERCENTAGE OF FAULT DETECTION BY BIT/ETE											
FALSE ALARM RATE OR FALSE STATUS INDICATION											
FAULT ISOLATION AMBIGUITY LEVEL											
PERCENT OF FAULT ISOLATION USING BIT/ETE											
SYSTEM MTBF											
MAINTENANCE PERSONNEL SKILL LEVEL											
BIT/ETE RELIABILITY											
BIT/ETE WEIGHT/VOLUME											
OTHERS:											

BIT/ETE QUESTIONAIRE — PART II

FIGURE OF MERIT COMPATABILITY CHECKLIST

HARDWARE TYPE(S):

MISSION TYPE(S):

INTERVIEWEE:

SCORING:
RATE EACH FOM ON A SCALE OF 1 TO 10 WITH 10 BEING THE HIGHEST RATING

	PERCENTAGE OF FAULT DETECTION BY BIT/ETE	FALSE ALARM RATE OR FALSE STATUS INDICATION	FAULT ISOLATION AMBIGUITY LEVEL	PERCENT OF FAULT ISOLATION USING BIT/ETE	SYSTEM MTBF		MAINTENANCE PERSONNEL SKILL LEVEL	BIT/ETE RELIABILITY	BIT/ETE WEIGHT/VOLUME	OTHERS:				
TRANSLATABILITY: (EASE OF TRANSLATION INTO DESIGNER TERMINOLOGY AND APPLICATION)														
TRACKABILITY: (EASE OF EVALUATING SATISFACTORY IMPLEMENTATION OF BIT/ETE REQUIREMENT)														
DEMONSTRATABILITY: (EASE OF DEMONSTRATING OR TESTING THAT DESIGN MEETS REQUIREMENTS)														
AMBIGUITY: (CLARITY OF FOM DEFINITION; EASE OF DEFINING IN QUANTITATIVE TERMS)														
GENERALITY: (APPLICABILITY OVER WIDE BAND OF SYSTEM/EQUIPMENT TYPES)														
COST: (RELATIVE COST OF IMPLEMENTING A DESIGN SATISFYING REQUIREMENT)														

SEND FINAL REPORT TO:	NOTES/COMMENTS:

Figure 2. BIT/ETE Survey Questionnaire

ambiguity, generality, and cost. The results obtained through this part of the survey consisted of scores (ranging from 1 to 10, with 10 being the best possible score) for each FOMs suitability factors. Since the scoring checklists results did not show very high correlation (i.e., a majority of the scores range from 1 to 10 for each FOM) the results will be used only as a guideline in the assignment of scores in the BIT/ETE Evaluation Task (Section 4). A summary of the average scores obtained for each BIT/ETE FOM is provided in Tables 5 through 9. The raw data is also provided in Appendix C.

TABLE 5. BIT/ETE INDUSTRY SURVEY SUMMARY – ALL EQUIPMENT TYPES

FOM	Suitability Factor						
	Translatability	Trackability	Demonstratability	Ambiguity	Generality	Cost	Avg
Percent of Fault Detection by BIT/ETE	7.0	6.0	6.7	6.4	7.1	6.4	6.6
False Alarm Rate/ False Status Indication	4.3	3.6	4.6	4.8	4.6	6.7	4.8
Fault Isolation Ambiguity Level	4.8	4.2	6.2	4.6	5.4	5.4	5.1
System MTBF	8.1	8.7	9.0	8.4	9.2	6.2	8.3
Maintenance Personnel Skill Level	6.2	6.2	6.7	5.5	6.5	5.3	6.1
BIT/ETE Reliability	7.3	8.7	5.7	6.8	7.0	5.8	6.7
BIT/ETE Weight/volume	7.3	7.7	7.8	7.5	6.0	3.6	6.8
Percent of Fault Isolation Using BIT/ETE	6.9	5.5	6.3	6.1	6.1	5.7	6.1

TABLE 6. BIT/ETE INDUSTRY SURVEY SUMMARY – AVIONICS

FOM	Suitability Factor						
	Translatability	Trackability	Demonstratability	Ambiguity	Generality	Cost	Avg
Percentage of Fault Detection by BIT/ETE	6.9	5.8	6.1	6.8	6.9	6.0	6.4
False Alarm Rate/ False Status Indication	6.1	3.9	4.9	4.9	5.0	6.9	5.1
Fault Isolation Ambiguity Level	5.2	4.3	6.2	5.3	5.3	5.0	5.2
System MTBF	7.9	8.7	8.8	8.3	8.7	5.9	8.1
Maintenance Personnel Skill Level	7.1	6.7	7.3	6.0	6.1	5.7	6.5
BIT/ETE Reliability	7.1	6.9	5.4	6.2	6.6	4.8	6.2
BIT/ETE Weight/Volume	7.0	7.2	7.6	7.0	5.6	3.3	6.3
Percent of Fault Isolation Using BIT/ETE	6.8	5.6	6.0	6.3	5.6	5.0	5.9

TABLE 7. BIT/ETE INDUSTRY SURVEY SUMMARY – GROUND

FOM	Suitability Factor						
	Translatability	Trackability	Demonstratability	Ambiguity	Generality	Cost	Avg
Percentage of Fault Detection by BIT/ETE	7.2	5.8	7.0	5.8	7.5	6.5	6.6
False Alarm Rate/ False Status Indication	2.8	2.6	4.4	5.4	4.2	6.5	4.3
Fault Isolation Ambiguity Level	3.3	3.7	6.2	4.9	6.2	5.8	5.0
System MTBF	7.9	8.5	9.2	9.5	9.4	6.6	8.5
Maintenance Personnel Skill Level	5.7	6.0	6.5	5.6	7.4	4.8	6.0
BIT/ETE Reliability	9.0	9.7	6.3	8.7	9.0	4.5	7.9
BIT/ETE Weight/Volume	8.0	8.5	9.0	9.0	5.0	3.0	7.1
Percent of Fault Isolation Using BIT/ETE	7.2	5.0	7.0	6.0	7.2	6.8	6.5

TABLE 8. BIT/ETE INDUSTRY SURVEY SUMMARY – SHIPBOARD

FOM	Suitability Factor						
	Translatability	Trackability	Demonstratability	Ambiguity	Generality	Cost	Avg
Percentage of Fault Detection by BIT/ETE	7.1	6.1	6.7	5.7	7.3	6.4	6.6
False Alarm Rate/ False Status Indication	3.5	2.8	3.3	3.8	4.8	7.8	4.3
Fault Isolation Ambiguity Level	5.0	4.3	5.7	3.5	5.5	5.6	4.9
System MTBF	8.1	8.0	8.9	9.0	9.5	7.0	8.4
Maintenance Personnel Skill Level	3.8	4.0	4.9	3.4	7.1	6.2	4.9
BIT/ETE Reliability	8.0	7.4	5.2	7.3	8.2	4.3	6.8
BIT/ETE Weight/Volume	5.3	7.0	7.0	7.0	6.0	4.0	6.0
Percent of Fault Isolation Using BIT/ETE	6.3	4.7	6.1	5.0	5.2	6.2	5.6

TABLE 9. BIT/ETE INDUSTRY SURVEY SUMMARY – MISSILE

FOM	Suitability Factor						
	Translatability	Trackability	Demonstratability	Ambiguity	Generality	Cost	Avg
Percentage of Fault Detection by BIT/ETE	6.0	7.5	8.5	6.0	7.0	8.5	7.2
False Alarm Rate/ False Status Indication	10.0	10.0	10.0	10.0	7.0	8.0	9.2
Fault Isolation Ambiguity Level	1.0	1.0	1.0	1.0	1.0	1.0	1.0
System MTBF	6.0	8.5	9.0	8.5	9.0	7.5	8.1
Maintenance Personnel Skill Level	6.0	8.5	9.0	8.5	8.0	7.0	7.8
BIT/ETE Reliability	1.0	1.0	1.0	1.0	1.0	1.0	1.0
BIT/ETE Weight/Volume	–	–	–	–	–	–	–
Percent of Fault Isolation Using BIT/ETE	9.0	9.0	5.0	9.0	7.0	6.0	8.0

2.5 DATA COLLECTION SUMMARY

The data collection tasks (literature search, system specification survey, and industry survey) have resulted in the identification of eighteen generic BIT/ETE FOMs that have been used in prior system specifications. These BIT/ETE FOM types are:

1) fraction of faults detected (FFD)
2) fraction of false alarms (FFA)
3) fraction of false status indications (FFSI)
4) mean fault detection time (T_{FD})
5) mean BIT/ETE running time (T_B)
6) frequency of BIT/ETE executions (F_B)
7) test thoroughness (TT)
8) fault isolation resolution (FIR(L))
9) fraction of faults isolated (FFI)
10) mean fault isolation time (T_{FI})
11) maintenance personnel skill level (MPSL)
12) BIT/ETE maintainability ($MTTR_{B/E}$)
13) BIT/ETE reliability ($MTBF_{B/E}$)
14) BIT/ETE availability ($A_{B/E}$)
15) MTTR
16) A
17) memory allocated for BIT/ETE (FMAB)
18) physical characteristic FOMs (e.g., weight, cost, etc...)

Currently there are no standardized techniques available for analyzing or demonstrating BIT/ETE FOMs. The only techniques that exist are maintainability analysis and demonstration techniques (e.g., MIL-HDBK-472, MIL-STD-471, RADC-TR-70-89, RADC TR-78-169, etc...). However these techniques can only be used to measure a few of the FOMs identified above. The remainder of this report concentrates on the development of analysis/demonstration techniques for the most suitable FOMs that are listed.

3.0 BIT/ETE FOM IDENTIFICATION

This section examines the basic objectives of specifying BIT/ETE FOM requirements, reviews and uniquely defines the currently used FOMs identified in Section 2, correlates the current FOMs with the defined objectives, and identifies new FOMs required to adequately address all BIT/ETE objectives.

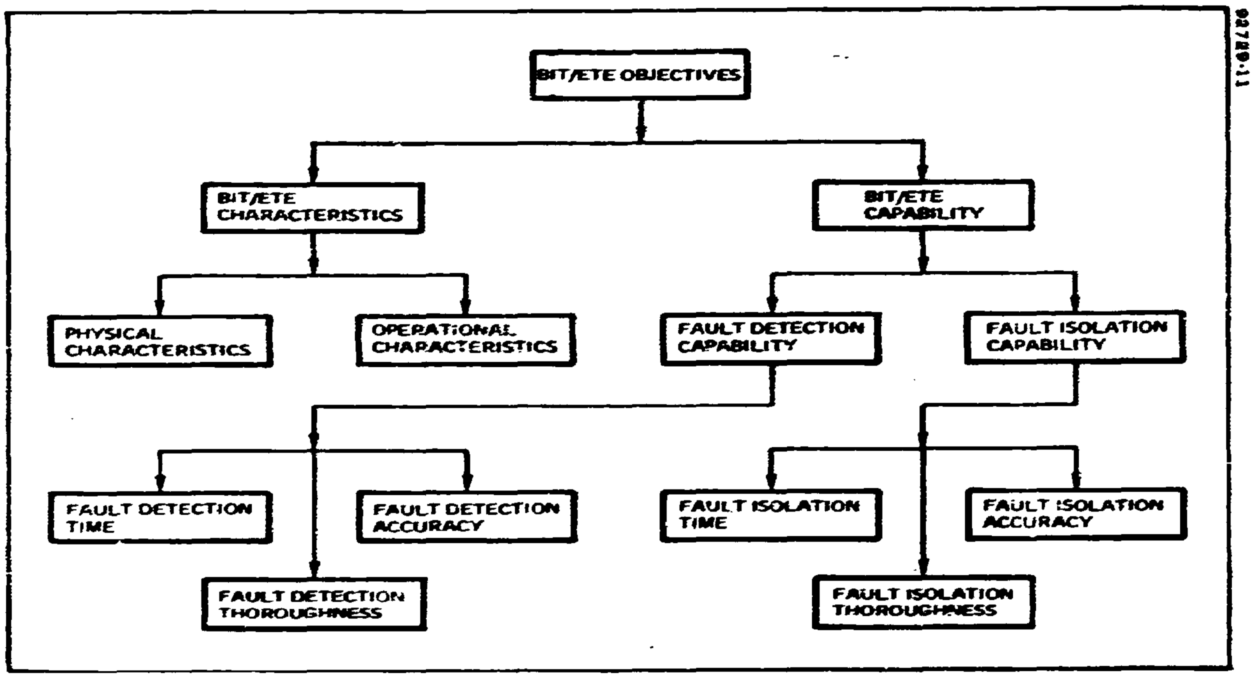

Figure 3. Categorization of BIT/ETE Objectives

3.1 IDENTIFICATION OF THE BIT/ETE OBJECTIVES

The objectives of BIT/ETE can be broken down into two distinct categories as shown in Figure 3. The first category considers the characteristics of the BIT/ETE itself, and the second category considers the actual performance capabilities of the BIT/ETE.

The characteristics of BIT/ETE can be further broken down into the physical characteristics of BIT/ETE (e.g., weight, volume, component count), and the operational characteristics of BIT/ETE (e.g., BIT/ETE reliability, maintainability). It should be noted that while BIT/ETE characteristics do not directly relate to the performance capability of BIT/ETE, generally the larger the physical attributes of the BIT/ETE the greater the BIT/ETE capability. Likewise the lower the BIT/ETE reliability is, the greater the complexity and correspondingly the greater the capability.

The BIT/ETE capability is further subdivided into the fault detection capability of the BIT/ETE, and the fault isolation capability of the BIT/ETE. Within these subdivisions the BIT/ETE capability is broken down into three main objectives:

1) how much time it takes to detect a fault (or isolate a fault)
2) how thorough is the BIT/ETE fault detection (or fault isolation) function
3) how accurate is the BIT/ETE fault detection (or fault isolation) function.

Since the primary objectives of specifying BIT/ETE FOMs relate to performance capabilities or operational considerations, the remainder of this report will concentrate in these areas. The BIT/ETE physical characteristics are straight forward and require no unique methodology for analysis or demonstration.

3.2 DEFINITION OF IDENTIFIED BIT/ETE FOMs

Of the eighteen general BIT/ETE FOM types identified thru the data collection task, sixteen of them pertain to BIT/ETE capabilities and operational characteristics. The remaining two generic FOMs (memory allocated for BIT/ETE and physical characteristic FOMs), are related to the physical characteristics of BIT/ETE and will not be further analyzed or discussed in the succeeding sections. Table 10 contains a summary of the sixteen BIT/ETE FOMs (i.e., FOMs related to BIT/ETE capabilities and operational characteristics), their definitions, and the general model for determining them.

For the FOMs defined with "detected faults", "detectable faults" can be interchanged with "detected faults" and the FOM definition will still be valid. For the purposes of this study "detectable faults" refers to faults that can be detected when evaluating a FOM by analysis, and "detected faults" refers to faults that are detected when evaluating a FOM by a formal demonstration. For simplification, only "detected faults" will be addressed for the remainder of this report.

It should be noted, that the models presented in this section are of general forms. Specific models to quantify each FOM, either by analysis or demonstrating are presented in later sections.

3.2.1 Definition of Fault

The definition of most BIT/ETE FOMs includes a reference to faults or failures. The definition of these terms can significantly affect the BIT/ETE FOM meaning and must be clearly understood. As defined in MIL-STD-721 and MIL-STD-1309, a failure is defined as:

> The inability of an item to perform within previously specified limits, or a malfunction that causes degradation or complete loss of equipment performance.

As defined in MIL-STD-1309, a fault is defined as:

> A degradation in performance due to detuning, maladjustment, misalignment, failure of parts, and so forth.

In general application, faults typically include any hardware abnormality whereas failures only include those faults which affect equipment (subsystem, system, etc.) performance or mission accomplishment. In practice, the application of a failure/fault definition is equipment or mission related and should be defined in the equipment specification. For purposes of this report all

TABLE 10. SUMMARY OF DEFINITIONS

#	Figure of Merit	Definition	General Model
1	Fraction of Faults Detected (FFD)	a) the fraction of all faults detected (or detectable) by BIT/ETE. b) the fraction of all detectable faults detected (or detectable) with BIT/ETE.	$FFD_A = \frac{\text{quantity of faults detected by BIT/ETE } (Q_{BDF})}{\text{quantity of all faults } (Q_F)}$ $FFD_D = \frac{\text{quantity of faults detected by BIT/ETE } (Q_{BDF})}{\text{quantity of faults detected } (Q_{FD})}$
2	Fraction of False Alarms (FFA)	the fraction of all BIT/ETE indicated faults which are false alarms. False Alarms are those indications of a fault when an actual fault has not occurred.	$FFA = \frac{\text{quantity of BIT/ETE false alarms } (Q_{FA})}{\text{quantity of all BIT/ETE indicated faults } (Q_{BIF})}$
3	Fraction of False Status Indications (FFSI)	The fraction of BIT/ETE fault indications (or lack thereof) which are erroneous.	$FFSI = \frac{\left\{\text{quantity of false alarms } (Q_{FA})\right\} + \left\{\text{quantity of undetected faults } (Q_{UD})\right\}}{\left\{\text{quantity of BIT/ETE indicated faults } (Q_{BIF})\right\} + \left\{\text{quantity of undetected faults } (Q_{UD})\right\}}$
4	Mean Fault Detection Time (T_{FD})	The average time it takes for BIT/ETE function to detect and indicate a fault from the time the fault has occurred.	$T_{FD} = \frac{\sum_{i=1}^{Q_{BDF}} (\text{time to detect and indicate the } i^{th} \text{ BIT/ETE detectable fault})}{Q_{BDF}}$
5	Mean BIT/ETE Running Time (T_B)	The average active time to perform a BIT/ETE routine. This can be the average for one test, a group of tests, or all tests.	$T_B = \frac{\sum_{i=1}^{NB} (\text{active running time of the } i^{th} \text{ BIT/ETE test routine, } T_{B_i})}{\text{the number of BIT/ETE test routines } (N_B)}$
6	Frequency of BIT/ETE Executions (F_B)	The frequency (or cycling rate) at which periodic BIT/ETE tests are executed (This does not apply to BIT/ETE tests that are executed only upon requests).	$F_B = \left\{\text{[the time it takes to execute the complete set of BIT/ETE test routines]} + \text{[the idle time between the execution of the complete set of BIT/ETE test routines]}\right\}^{-1}$
7	Test Thoroughness (TT)	The fraction of the equipment/system tested by BIT/ETE relative to the entire equipment/system.	$TT = \frac{\text{(amount of system/equipment tested by BIT/ETE)}}{\text{(amount of system/equipment tested by BIT/ETE)} + \text{(amount of system equipment not tested by BIT/ETE)}}$
8	Fault Isolation Resolution (FIR(L))	The fraction of detected faults isolated by BIT/ETE down to an acceptable (specified) minimum number of replaceable items.	$FIR(L) = \frac{\text{quantity of detected faults isolatable to} \le L \text{ RIs with BIT/ETE } (Q_{IL})}{\text{quantity of detected faults } (Q_{FD})}$
9	Fraction of Faults Isolated (FFI)	The fraction of faults detected by BIT/ETE, isolated with BIT/ETE to the replacement level specified by the maintenance concept.	$FFI = \frac{\text{quantity of detected faults isolated with BIT/ETE } (Q_{IB})}{\text{quantity of faults detected } (Q_{FD})}$
10	Mean Fault Isolation Time (T_{FI})	The average time to complete the fault isolation process using BIT/ETE.	$T_{FI} = \frac{\sum_{i=1}^{Q_{BDF}} (\text{time to isolate the } i^{th} \text{ fault with BIT/ETE})}{Q_{BDF}}$
11	Maintenance Personnel Skill Level (MPSL)	a) the average skill level required to perform corrective maintenance for a system/equipment b) the minimum skill level required to perform corrective maintenance on a system/equipment	Not Applicable
12	BIT/ETE Reliability ($MTBF_{B/E}$)	The probability that the BIT/ETE circuitry will perform its intended function for a specified interval under specified conditions. BIT/ETE circuitry is any hardware that is used for BIT/ETE testing that is not common to the system hardware.	$MTBF_{B/E} = [\lambda_{B/E}]^{-1} = \left\{\sum_{k=1}^{N_{B/E}} \lambda_{B/E_k}\right\}^{-1}$ $N_{B/E}$ = quantity of BIT/ETE hardware components not common to system hardware
13	BIT/ETE Maintainability [illegible]	The average time to repair a fault in the BIT/ETE [illegible]	$N_{B/E}$ [illegible]

7	Test Thoroughness (TT)	The fraction of the equipment/system tested by BIT/ETE relative to the entire equipment/system.	$TT = \frac{\text{(amount of system/equipment tested by BIT/ETE)}}{\text{(amount of system/equipment tested by BIT/ETE)} + \text{(amount of system equipment not tested by BIT/ETE)}}$
8	Fault Isolation Resolution (FIR(L))	The fraction of detected faults isolated by BIT/ETE down to an acceptable (specified) minimum number of replaceable items.	$FIR(L) = \frac{\text{quantity of detected faults isolatable to} \le L \text{ RIs with BIT/ETE } (Q_{IL})}{\text{quantity of detected faults } (Q_{FD})}$
9	Fraction of Faults Isolated (FFI)	The fraction of faults detected by BIT/ETE, isolated with BIT/ETE to the replacement level specified by the maintenance concept.	$FFI = \frac{\text{quantity of detected faults isolated with BIT/ETE } (Q_{IB})}{\text{quantity of faults detected } (Q_{FD})}$
10	Mean Fault Isolation Time (T_{FI})	The average time to complete the fault isolation process using BIT/ETE.	$T_{FI} = \frac{\sum_{i=1}^{Q_{BDF}} \text{(time to isolate the } i^{th} \text{ fault with BIT/ETE)}}{Q_{BDF}}$
11	Maintenance Personnel Skill Level (MPSL)	a) the average skill level required to perform corrective maintenance for a system/equipment b) the minimum skill level required to perform corrective maintenance on a system/equipment	Not Applicable
12	BIT/ETE Reliability ($MTBF_{B/E}$)	The probability that the BIT/ETE circuitry will perform its intended function for a specified interval under specified conditions. BIT/ETE circuitry is any hardware that is used for BIT/ETE testing that is not common to the system hardware.	$MTBF_{B/E} = [\lambda_{B/E}]^{-1} = \left\{ \sum_{k=1}^{N_{B/E}} \lambda_{B/E_k} \right\}^{-1}$ $N_{B/E}$ = quantity of BIT/ETE hardware components not common to system hardware
13	BIT/ETE Maintainability ($MTTR_{B/E}$)	The average time to repair a fault in the BIT/ETE hardware.	$MTTR_{B/E} = \frac{\sum_{k=1}^{N_{B/E}} \lambda_{B/E_k} M_{CT\,k}}{\sum_{k=1}^{N_{B/E}} \lambda_{B/E\,k}}$
14	BIT/ETE Availability ($A_{B/E}$)	A measure of the degree to which the BIT/ETE circuitry is in the operable and committable state at the start of a mission, when the mission is called for at an unknown (random) point in time.	$A_{B/E} = \frac{MTBF_{B/E}}{MTBF_{B/E} + MTTR_{B/E}}$
15	System Maintainability (MTTR)	The average corrective maintenance time for all system/equipment faults.	$MTTR = \frac{\sum_{i=1}^{N} \lambda_i M_{ct_i}}{\sum_{i=1}^{N} \lambda_i}$
16	System Availability (A)	A measure of the degree to which a system/equipment is in the operable and committable state at the start of a mission, when the mission is called for at an unknown (random) point in time.	$A = \frac{MTBF}{MTBF + MTTR}$
17	Fraction of False Pulls (FFP)	The fraction of RIs removed from a system, due to the result of a BIT/ETE fault isolation process, that are good RIs (i.e., RIs with no actual failure within it).	$FFP = \frac{\text{quantity of good RIs removed } (Q_{GRI})}{\text{quantity of RIs removed } (Q_{RR})}$
18	Fraction of Erroneous Fault Isolation Results (FEFI)	The fraction of BIT/ETE fault isolation results that identify the wrong RI once a fault has been detected.	$FEFI = \frac{\text{quantity of erroneous fault isolation results, } (Q_{EFIR})}{\text{quantity of fault isolation results, } (Q_{FIR})}$

BIT/ETE FOM definitions reference faults as opposed to failures. The definitions are not restricted however and can apply to failures as well, if so desired, and if properly defined in the equipment specification.

3.2.2 Fraction of Faults Detected (FFD)

The fraction of faults detected by BIT/ETE (FFD) can be expressed two ways: 1) the fraction of all faults detected by BIT/ETE (FFD_A), and 2) the fraction of all detected faults detected by BIT/ETE (FFD_D).

FFD_A is defined as the fraction of all faults that can occur, which are detected by the BIT (and/or ETE) function. This is represented by the following model:

$$FFD_A = \frac{\text{quantity of faults detected by BIT/ETE } (Q_{BDF})}{\text{quantity of all faults } (Q_F)}$$

FFD_D is defined as the fraction of faults that can be detected, which are detected by the BIT (and/or ETE) function. This is represented by the following model:

$$FFD_D = \frac{\text{quantity of faults detected by BIT/ETE } (_{BDF})}{\text{quantity of faults detected } (Q_{FD})}$$

For the above definitions the following ground rules have been established:

1) the quantity of all faults (Q_F), the quality of faults detected by BIT/ETE (Q_{BDF}), and the quantity of faults detected (Q_{FD}) exclude the occurrence of false alarms (false alarms are defined in Section 3.2.3).
2) intermittent faults are classified as a single fault, thus Q_F, Q_{FD}, and Q_{BD} include the occurrence of intermittent faults only once.
3) temporary faults (faults caused by external transients or noise) are not classified as faults, therefore they are excluded from Q_F, Q_{FD}, and Q_{BFD}.

3.2.3 Fraction of False Alarms (FFA)

The Fraction of False Alarms (FFA) is defined as the fraction of all BIT/ETE fault indications which are false alarms. False alarms are those indications of a fault when an actual fault has not occurred. FFA is represented by the following model:

$$FFA = \frac{\text{quantity of BIT/ETE false alarms } (Q_{FA})}{\text{quantity of all BIT/ETE indicated failures } (Q_{BIF})}$$

False alarms are dependent upon several factors. First of all, false alarms are dependent upon the BIT/ETE philosophy. If BIT/ETE is considered an integral part of the system (i.e., BIT/ETE are considered part of the system/equipment), then Table 11 below summarizes when a false alarm will occur.

TABLE 11. OCCURRENCE OF FALSE ALARMS WITH INTEGRAL BIT/ETE

Status of the BIT/ETE	Equipment Status Indicated by BIT/ETE	BIT/ETE Indication Status Relative to the Actual Equipment Status	
		Equipment is UP	Equipment is DOWN
up	up	OK – operational	undetected fault
up	down	false alarm	OK – detected fault
down	up	undetected fault	undetected fault
down	down	OK – detected fault	OK – detected fault (dual)

If BIT/ETE is independent of the system (i.e., BIT/ETE faults are not considered system/equipment faults), then Table 12 below summarizes when a false alarm will occur.

TABLE 12. OCCURRENCE OF FALSE ALARMS WITH INDEPENDENT BIT/ETE

Status of the BIT/ETE	Equipment Status Indicated by BIT/ETE	BIT/ETE Indication Status Relative to the Actual Equipment Status	
		Equipment is UP	Equipment is DOWN
up	up	OK – operational	undetected fault
up	down	false alarm	OK – detected fault
down	up	OK – operational	undetected fault
down	down	false alarm	OK – detected fault

False alarms are categorized into three types as follows:

1) Faulty BIT/ETE function – If a BIT/ETE fault occurs which indicates the equipment is down when it is actually operational then a false alarm has occurred.

2) out-of-tolerance conditions – False alarms caused by out-of-tolerance conditions occur when the BIT/ETE measures an internal signal and determines it to be out of tolerance, when the actual output signal (the signal of importance) is still within its specified tolerance bounds. These types of false alarms are largely dependent upon the circuit and/or BIT/ETE designer(s) who set the tolerance bounds for each signal.

3) transient conditions – Fault indications caused by transient conditions can be classified as false alarms if the transient does not result in a true fault condition.

There are several conditions that may be thought of as false alarms when actual faults have occurred. Fault conditions that are not false alarms include:

- intermittents – faults that exist only temporarily (e.g., a fault indicated in an airborne environment that can not be recreated (or verified) on the ground).
- transients that result in temporary faults i.e., the transient results in a fault condition and as a result, also causes a temporary failure in the system/equipment.

3.2.4 Fraction of False Status Indications (FFSI)

The fraction of false status indications (FFSI) is an extension of FFA. FFSI is defined as the fraction of BIT/ETE fault indications (or lack thereof) which are erroneous. FFSI can be represented by the following model:

$$FFSI = \frac{\left\{\text{quantity of false alarms } (Q_{FA})\right\} + \left\{\text{quantity of undetected faults } (Q_{UD})\right\}}{\left\{\text{quantity of BIT/ETE indicated faults } (Q_{BIF})\right\} + \left\{\text{quantity of undetected faults } (Q_{UD})\right\}}$$

Inspection of Tables 11 and 12 indicates when false alarms and undetected faults will occur (relative to the classification of BIT/ETE faults). It will be shown later on (Section 6.2.1) that FFSI must be greater than or equal to FFA.

3.2.5 Mean Fault Detection Time (T_{FD})

The mean fault detection time (T_{FD}) is the average time it takes for the BIT/ETE function to detect and indicate a fault from the time that the fault has occurred. T_{FD} can be represented by the following model:

$$T_{FD} = \frac{\sum_{i=1}^{Q_{BDF}} \text{(time to detect and indicate the } i^{th} \text{ BIT/ETE detectable fault)}}{Q_{BDF}}$$

3.2.6 Mean BIT/ETE Running Time (T_B)

The mean BIT/ETE running time (T_B) is defined as the average active time to perform a BIT/ETE test routine. This can be the average for one test, a group of tests, or all tests. T_B can be represented by the following model:

$$T_B = \frac{\sum_{i=1}^{N_B} (\text{active running time of the } i^{th} \text{ BIT/ETE test routine, } T_{Bi})}{\text{the number of BIT/ETE test routines } (N_B)}$$

The actual measurement of T_B is dependent upon how BIT is set up and how the user wants to define T_B. Some factors that must be considered when determining T_B are:

- which BIT/ETE function(s) is T_B being computed for?
- does T_B refer to fault detection, fault isolation, or both?
- are BIT/ETE tests serial or overlapping?
- are BIT/ETE tests continuous or time shared?
- is T_B the running time with or without a fault found?
- for fault detection, does the BIT/ETE test stop upon detection or continue to the end?
- is the BIT/ETE test periodic or performed as requested?

Generally (and for the purpose of this report) T_B will be limited to the following cases

- fault detection only
- periodic BIT/ETE tests only
- continuous or time shared BIT/ETE tests
- serial BIT/ETE tests
- all BIT/ETE functions
- with or without fault found
- stop upon fault detection or continue to end

3.2.7 Frequency of BIT/ETE Executions (F_B)

The frequency of BIT/ETE executions is defined as the frequency (or cycling rate) at which periodic BIT/ETE tests are executed. This does not apply to BIT/ETE tests that are executed only upon request. F_B can be represented by

$$F_B = \left\{ \begin{array}{l} \text{[the time it takes to execute the complete set of BIT/ETE test routines]} \\ + \text{[the idle time between the execution of the complete set of BIT/ETE test routines]} \end{array} \right\}^{-1}$$

A cycle is defined as the time from the start of a given BIT/ETE test until the same test is started again. For cases where all tests do not have the same periodicity, the cycle time is considered to be the larger cycle time of all the BIT/ETE tests. For example, Figure 4 shows the cycle time for two BIT/ETE test routines. The cycle time for the tests combined (Tests 1 & 2) is equal to the largest cycle time of the two tests, namely Test #2.

3.2.8 Test Thoroughness (TT)

Test thoroughness is defined as the fraction of the equipment/system tested by BIT/ETE relative to the entire equipment/system. TT can be represented by

$$TT = \frac{\text{(amount of system/equipment tested by BIT/ETE)}}{\text{(amount of system/equipment tested by BIT/ETE)} + \text{(amount of system equipment not tested by BIT/ETE)}}$$

There are several different measures that can be used to quantify the amount of a system/equipment tested or untested. Some possible parameters of measure are:

- failure rate (λ) tested and untested
- number of functions tested and untested
- number of components tested and untested
- number of faults tested and untested

It should be noted that, if the parameter of measure is the same as is used for FFD, the two (FFD & TT) are not necessarily equal. However, if the two FOMs are evaluated at the same level (e.g., component failure mode level) then FFD and TT will be equal.

3.2.9 Fault Isolation Resolution (FIR(L))

Fault isolation resolution (FIR(L)) is defined as the fraction of detectable faults that can be isolated by BIT/ETE down to an acceptable (specified) minimum number of replaceable items (RIs). FIR(L) can be represented by

$$FIR(L) = \frac{\left\{\begin{array}{l}\text{quantity of detected faults isolated} \\ \text{to} \le L \text{ RIs with BIT/ETE, } (Q_{IL})\end{array}\right\}}{\text{quantity of detected faults, } (Q_{FD})}$$

When FIR(L) is specified, it is usually specified for more than one L.

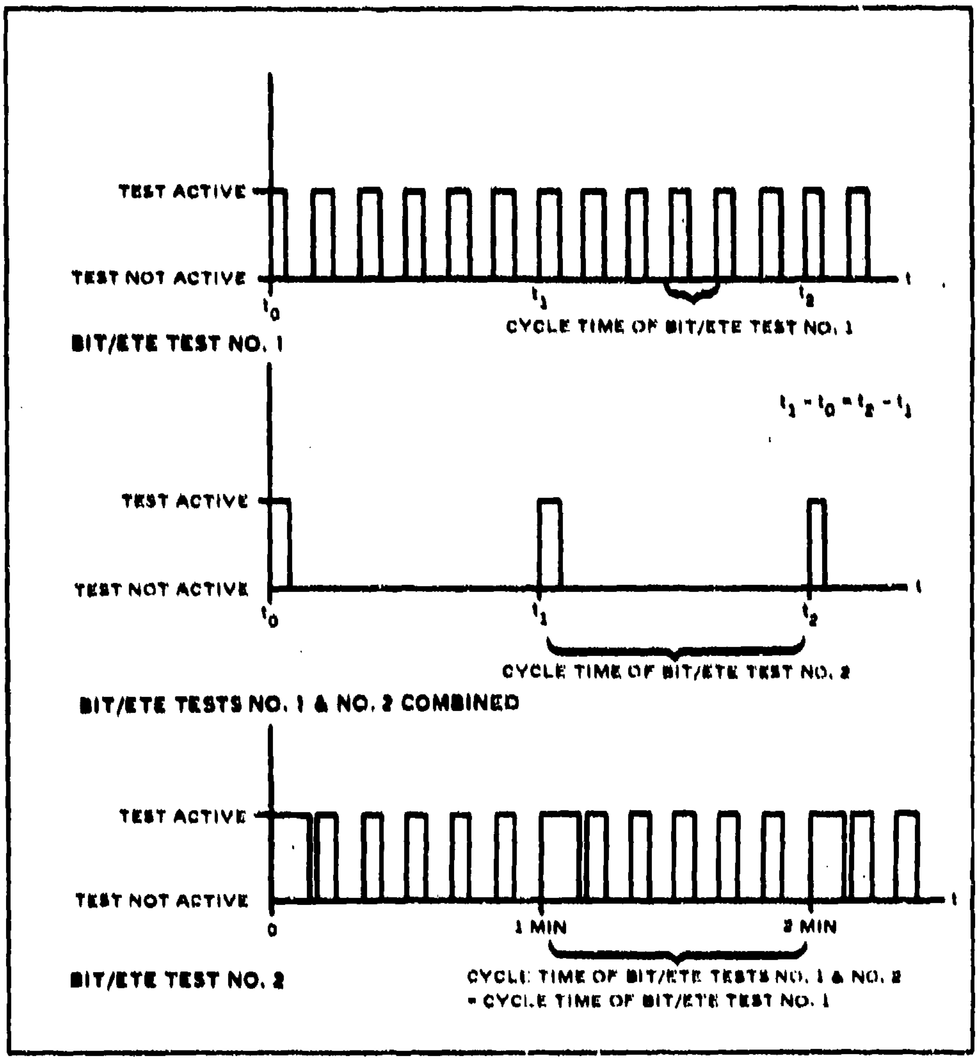

Figure 4. Cycle Time for Individual BIT/ETE Test Routines and Their Combined Cycle Times

3.2.10 Fraction of Faults Isolated by BIT/ETE (FFI)

The fraction of faults isolated (FFI) by BIT/ETE is a generalization of FIR(L). FFI can be defined as the fraction of faults, detected by BIT/ETE, isolated by BIT/ETE to the replacement level specified by the maintenance concept. FFI can be represented by:

$$FFI = \frac{\text{quantity of detected faults isolated with BIT/ETE } (Q_{IB})}{\text{quantity of faults detected } (Q_{FD})}$$

3.2.11 Mean Fault Isolation Time (T_{FI})

The mean fault isolation time (T_{FI}) is defined as the average time to complete the fault isolation process using BIT/ETE. T_{FI} can be represented by

$$T_{FI} = \frac{\sum_{i=1}^{Q_{BDF}} \text{(time to isolate the } i^{th} \text{ fault with BIT/ETE)}}{\text{quantity of faults detected, } (Q_{BDF})}$$

3.2.12 Maintenance Personnel Skill Level (MPSL)

Maintenance personnel skill level (MPSL) can be defined two different ways. One way is to define MPSL as the average skill level required to perform corrective maintenance for a system/equipment. MPSL can also be defined as the minimum skill level (i.e., skill level with the lowest ability) required to perform corrective maintenance on a system/equipment. For the purpose of this study, the latter definition will be used since the appearance of this FOM in specifications typically means that the skill level available will be limited.

3.2.13 BIT/ETE Reliability ($MTBF_{B/E}$)

The BIT/ETE Reliability ($MTBF_{B/E}$) is defined as the probability that the BIT/ETE circuitry will perform its intended function for a specified interval under specified conditions. BIT/ETE circuitry is any hardware that is used for BIT/ETE testing that is not common to the system hardware. $MTBF_{B/E}$ can be represented by:

$$MTBF_{B/E} = \left[\lambda_{B/E}\right]^{-1} = \left[\sum_{k=1}^{N_{B/E}} \lambda_{B/E_k}\right]^{-1}$$

where: λ_{B/E_k} = failure rate of the k^{th} BIT/ETE hardware component

$N_{B/E}$ = quantity of BIT/ETE hardware components not common to system hardware

3.2.14 BIT/ETE Maintainability ($MTTR_{B/E}$)

BIT/ETE maintainability ($MTTR_{B/E}$) is defined as the average time to repair a fault in the BIT/ETE circuitry. $MTTR_{B/E}$ can be expressed several ways. One way of expressing $MTTR_{B/E}$ is by:

$$MTTR_{B/E} = \frac{\sum_{k=1}^{N_{B/E}} \lambda_{B/E_k} M_{CT_k}}{\sum_{k=1}^{N_{B/E}} \lambda_{B/E_k}}$$

where: M_{CT_k} is the repair time for the k^{th} BIT/ETE hardware component

λ_{B/E_k} failure rate of the k^{th} BIT/ETE hardware component

The above method was extracted from RADC-TR-78-169, Maintainability Prediction and Analysis Study. Other methods for determining $MTTR_{B/E}$ can be found in MIL-HDBK-472 and RADC-TR-70-89.

3.2.15 BIT/ETE Availability $A_{B/E}$)

BIT/ETE availability ($A_{B/E}$) is defined as a measure of the degree to which the BIT/ETE circuitry is in the operable and committable state at the start of a mission, when the mission is called for at an unknown (random) point in time. $A_{B/E}$ can be represented by:

$$A_{B/E} = \frac{MTBF_{B/E}}{MTBF_{B/E} + MTTR_{B/E}}$$

3.2.16 System Maintainability (MTTR)

System maintainability (MTTR) is defined as the average corrective maintenance time for all system/equipment faults. As with $MTTR_{B/E}$, MTTR can be represented several ways. One way is:

$$MTTR = \frac{\sum_{i=1}^{N} \lambda_i M_{CT_i}}{\sum_{i=1}^{N} \lambda_i}$$

where: N is the number of components in the system/equpment

λ_i = failure rate of the i^{th} component

M_{CT_i} = repair time for the i^{th} component

3.2.17 System Availability (A)

System Availability (A) is defined as a measure of the degree to which a system (or equipment) is in the operable and committable state at the start of a mission, when the mission is called for at an unknown (random) point in time. "A" can be expressed the same way as $A_{B/E}$.

$$A = \frac{MTBF}{MTBF + MTTR}$$

3.3 CATEGORIZATION OF THE IDENTIFIED BIT/ETE FOMs

The BIT/ETE FOMs defined in Section 3.2 were categorized according to the BIT/ETE objective(s) (identified in Section 3.1) that they fulfill.

Categorization of the FOMs defines how each identified FOM characterizes BIT/ETE and aids in determining what new FOMs may be needed. Categorization of the FOMs was also used in Section 6.0 for determining which FOMs are interrelated and for determining an appropriate set of FOMs that should be specified for a given application. Figure 5 indicates those BIT/ETE FOMs defined in Section 3.2 that are associated with each BIT/ETE objective. Some BIT/ETE FOMs appear under more than one BIT/ETE objective since they can characterize more than one facet of BIT/ETE. Also, it should be noted that not all the FOMs associated with any one BIT/ETE objective can be used to precisely quantify the objective or requirement. These particular FOMs are either qualitative measures or indirect quantitative measures of the same objective. However, they can still be used to impose requirements on the associated BIT/ETE objectives.

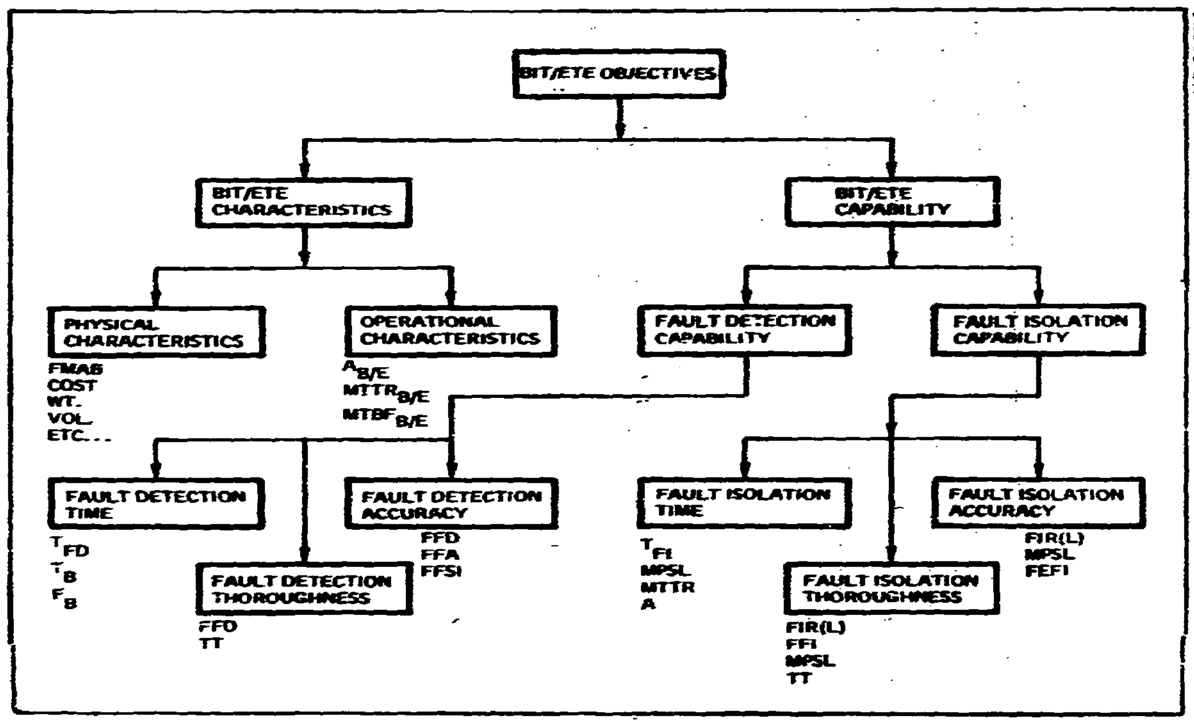

Figure 5. Correlation of BIT/ETE Objectives with Identified FOMs

3.4 IDENTIFICATION OF NEW BIT/ETE FOMs REQUIRED

The purpose of this task was to identify any new BIT/ETE FOMs required to fill in the voids in Figure 5 where a given BIT/ETE objective is not covered by an existing FOM. Inspection of Figure 5 indicates that all the BIT/ETE objectives have an associated FOM(s). Whether these FOMs are good measures of the objective is unknown (this will be determined later on in Section 4).

One area that may require a new FOM is the BIT/ETE objective, Fault Isolation Accuracy. The identified BIT/ETE FOM that quantifies this objective the best is FIR(L). However, FIR(L) is more of an indication on how thorough the BIT/ETE fault isolation function is rather than accuracy.

A possible new FOM may be the False Pull Rate (FPR) or the Fraction of False Pulls (FFP). FPR (or FFP) is defined as:

<u>FPR</u> – The rate at which good RIs (i.e., RIs with no actual failure within it) are removed from a system due to the result of a BIT/ETE fault isolation process.

or

<u>FFP</u> – The fraction of RIs removed from a system, due to the result of a BIT/ETE fault isolation process, that are good RIs (i.e., RIs with no actual failure within it).

$$FFP = \frac{\text{quantity of good RIs removed } (Q_{GRI})}{\text{quantity of RIs removed } (Q_{RR})}$$

The only problem associated with the use of FPR or FFP is that it is dependent upon the maintenance concept. That is, a system with a certain amount of BIT/ETE may have two different values for FPR (or FFP) given two different maintenance concepts. For example, assume a system with an average fault isolation resolution (i.e., average BIT/ETE fault isolation group size, $\bar{S}$) of three RIs. If the system's maintenance concept is "RI group replacement," then the FPR would be two out of every three RIs or 0.67 for FFP (i.e., on the average two good RIs are removed for every bad one). On the other hand, if the maintenance concept is "iterative RI replacement" (i.e., remove/replace RIs one at a time until the fault is corrected), then the FPR would be one out of two on the average (i.e., average number of iterations required to correct the fault is two) or 0.50 for FFP. It should be noted here that FIR(L) and FFP are very similar. As a matter of fact, FFP can be derived exactly through FIR(L). For example, for any given set of $FIR(L_i)$ (e.g., $0.90 \le 1$ RI, $0.95 \le 3$ RIs, and $1.0 \le 10$ RIs), an average fault isolation group size can be determined, $\bar{S}$ (i.e., $\bar{S}$ is the average RI group size that a fault can be isolated to). Depending upon the maintenance concept, FFP can easily be determined by:

if the maintenance concept was RI group replacement,

$$FFP = \frac{\bar{S} - 1}{\bar{S}}$$

if the maintenance concept was iterative RI replacement,

$$FFP = \frac{\frac{\bar{S}+1}{2} - 1}{\frac{\bar{S}+1}{2}} = \frac{\bar{S} - 1}{\bar{S} + 1}$$

Thus, for the remainder of this report, FPR & FFP will be excluded since they can be derived from FIR (L).

One other possible new BIT/ETE FOM is the erroneous fault isolation rate (EFIR), or the fraction of erroneous fault isolation results (FEFI). EFIR and FEFI are defined as:

EFIR – The rate at which a BIT/ETE fault isolation process results in identifying the wrong RI (i.e., fault isolation process results in a suspect group of RIs, but when the RIs are replaced, the fault still exists) once a fault has been detected.

FEFI – The fraction of BIT/ETE fault isolation results that identify the wrong RI once a fault has been detected.

$$FEFI = \frac{\text{quantity of erroneous fault isolation results, } (Q_{EFIR})}{\text{quantity of fault isolation results, } (Q_{FIR})}$$

EFIR and FEFI may be good choices of BIT/ETE FOMs to measure the accuracy of BIT/ETE fault isolation since they essentially measure how well the BIT/ETE fault isolation function has been documented (i.e., the number or rate of erroneous fault isolation results is largely dependent upon how well the BIT/ETE is documented in maintenance manuals and the software). Note that the software or the maintenance manuals used to present fault isolation results is also a part of the BIT/ETE, since a BIT/ETE function that is capable of isolating faults to a single RI is of no good if the results cannot be presented to the user correctly.

For the remainder of this report only FEFI (the fraction of erroneous fault isolation results) will be addressed, since EFIR is similar.

4.0 BIT/ETE FOM EVALUATION

The objective of this task was to evaluate the suitability of the FOMs defined in the preceding section as design specifications.

The approach used to evaluate the FOMs suitability was a weighted scoring technique. The steps involved in the approach were:

1) establish an evaluation criteria
2) score each FOM according to the established evaluation criteria
3) determine the scores for each FOM by a weighted scoring sum.

The following subsections contain the detailed information on the accomplishment of the above tasks.

4.1 EVALUATION CRITERIA

The factors used to determine the suitability of a BIT/ETE FOM for use as possible design specifications are: 1) ambiguity, 2) translatability, 3) trackability, 4) demonstratability, 5) applicability, and 6) uniqueness. A FOM must be unambiguous to establish a common baseline of what the FOM represents. A FOM must be translatable so the design engineer can interpret the specifications into terminology and quantitative requirements familiar to him. It must also be trackable so it can be evaluated during the various stages of a system's development to determine how much BIT/ETE has been designed into a system and how effective it is. A FOM must be demonstratable so the BIT/ETE can be evaluated to see if the requirements have been met. A FOM should be applicable to all system types in order to reduce the quantity of unique FOMs used. Finally, a FOM should characterize as many of the BIT/ETE characteristics as possible, in order to minimize the amount of BIT/ETE FOMs required for a single specification.

The six suitability factors mentioned in the previous paragraph were used as the scoring factors in the evaluation process. The precise definitions of each suitability factor were:

1) ambiguity – This scoring factor was used to determine how definitive a FOM is. That is, can a FOM be interpreted into its true definition without any difficulty, or can the definition be interpreted more than one way. The more definitive a FOM is, the higher it scored.
2) translatability – This scoring factor was used to determine how good a FOM is to the engineer as a design tool. In other words, can the engineer take the specified FOM and translate it into parameters that can be used in his design effort. The more useful a FOM is to the designer, the higher it scored.
3) trackability – This scoring factor was used to measure a FOM's stability to be quantified and evaluated during a system's various phases (e.g., conceptual, design, development, ...). The easier it was to quantify a FOM during these various phases, the higher it scored.

4) demonstratability – This scoring factor measures a FOM's ability to be quantitatively verified. This pertains to either formal demonstration, informal demonstration, or field usage. The easier it was to quantify a FOM via testing, the higher it scored.

5) applicability – This scoring factor was used to determine a FOM's usefulness towards various system types. The more system types a FOM was applicable to, the higher it scored.

6) uniqueness – This scoring factor was used to measure the overall effectiveness of specifying a FOM. That is, the more BIT/ETE objectives (fault detection and fault isolation were separated) a FOM characterized, the higher it scored.

Once the scoring factors were determined, weights were assigned to them according to their importance in BIT/ETE FOM specification. The scoring weights assigned to each factor are summarized in Table 13 below.

TABLE 13. SCORING FACTOR WEIGHTS

Suitability Factor	Weight
Ambiguity	12
Translatability	17
Trackability	20
Demonstratability	18
Applicability	8
Uniqueness	25

The rationale for selecting the weights was as follows:

1) Uniqueness – if a FOM did not characterize BIT/ETE (i.e., the BIT/ETE performance capabilities), it was of little use, thus uniqueness was considered the most important factor. (The goal was to find a minimum set of FOMs.)

2) Translatability, trackability, and demonstratability were assigned relatively the same weight. A FOM must be capable of being translated into design parameters, followed (tracked) through the various design/development stages, and verified through testing.

3) Finally, ambiguity and applicability were given the smallest weights since these two factors were not necessities. (i.e., it would be nice to have a FOM that was not ambiguous and was applicable to all system types, but a FOM could still be useful without these characteristics.)

With the evaluation criteria mentioned previously, it was possible to evaluate the FOMs using the following model:

$$\text{evaluation score} = \sum_{i=1}^{6} W_i S_i$$

where:

W_i = scoring weight of the i^{th} factor

S_i = score assigned to the i^{th} factor

i = scoring factor (ambiguity, translatability...)

The results of the evaluation process are summarized in the next section.

4.2 BIT/ETE EVALUATION RESULTS

Prior to evaluating the BIT/ETE FOMs, they were broken up into the major categories identified in Section 3. The categories in which they were grouped were: 1) BIT/ETE FOMs that characterize the BIT/ETE fault detection capabilities, 2) BIT/ETE FOMs that characterize the BIT/ETE fault isolation capabilities, and 3) BIT/ETE FOMs that characterize the operational characteristics of BIT/ETE. This was done to avoid the comparison of FOM types that were not applicable to the same FOM characteristic (i.e., the uniqueness suitability factor was scored for either fault detection capability or fault isolation capability, but not both). FOMs that measured BIT/ETE operational characteristics were scored on the basis of the first five suitability factors alone, since uniqueness is not applicable to these FOMs (these FOMs were scored zero for this factor).

Table 14 is a summary of the evaluation results. A majority of the BIT/ETE FOMs scored as expected, but there were a few surprises. Fraction of False Alarms (FFA) and Fraction of false Status Indications (FFSI) were expected to score high but actually scored very low. This was largely due to their inability to be translated, tracked and demonstrated with relative ease. The new FOM identified, Fraction of Erroneous Fault Results (FEFI) also scored low for the same reasons.

The BIT/ETE FOMs that scored well were RMA FOMs that are currently specified (A and MTTR). Fraction of Faults Detected (FFD) and Fault Isolation Resolution (FIR(L)) also scored relatively high as expected.

The results of the BIT/ETE FOM evaluation provide the basis for Section 6, the FOM guidelines section, in determining which FOMs should be specified over others. The overall objective was to determine which FOMs were the best to specify. However, this can not automatically rule out FOMs that scored low (i.e., FFA, FFSI, ...) in the evaluation process since the FOMs that are actually selected are also dependent upon the BIT/ETE objectives that are desired.

TABLE 14. SUMMARY OF BIT/ETE FOM EVALUATION SCORES

	Suitability Factors												
	Ambiguity Weight=12		Translatability Weight=17		Trackability Weight=20		Demonstratability Weight = 18		Applicability Weight=8		Uniqueness Weight=25		
FOMs	S	S·W	S	S·W	S	S·W	S	S·W	S	S·W	S	S·W	Σ(S·W)
Fault Detection Capability													
1. FFD	8	96	9	153	9	180	4	72	9	72	6	150	723
2. F_B	4	48	8	136	8	160	8	144	9	72	4	100	660
3. TT	5	60	9	153	9	180	2	36	9	72	5	125	626
4. T_B	3	36	7	119	8	160	8	144	9	72	3	75	606
5. T_{FD}	5	60	7	119	8	160	2	36	9	72	5	125	572
6. FFSI	5	60	4	68	3	60	5	90	9	72	6	150	500
7. FFA	5	60	3	51	1	20	3	54	9	72	2	50	307
Fault Isolation Capability													
1. MTTR	8	96	8	136	8	160	9	162	9	72	6	150	776
2. A	7	84	8	136	8	160	9	162	9	72	4	100	714
3. FIR(L)	9	108	5	85	7	140	6	108	9	72	7	175	688
4. FFI	7	84	5	85	7	140	6	108	9	72	6	150	639
5. TT	5	60	9	153	9	180	2	36	9	72	5	125	626
6. T_{FI}	5	60	6	102	5	100	8	144	9	72	5	125	603
7. FEFI	6	72	3	51	2	40	5	90	9	72	4	100	425
8. MPSL	1	12	1	17	1	20	3	54	9	72	1	25	200
BIT/ETE Characteristics*													
1. $MTBF_{B/E}$	7	84	9	153	9	180	9	162	9	72	0	-	651
2. $MTTR_{B/E}$	8	96	8	136	8	160	9	162	9	72	0	-	626
3. $A_{B/E}$	7	84	8	136	8	160	9	162	9	72	0	-	614

5.0 BIT/ETE FOM VERIFICATION TECHNIQUES

As stated previously in the Evaluation Section (Section 4), two of the most important aspects of BIT/ETE FOMs, are a FOM's ability to be analyzed and demonstrated. This section presents the models and techniques that have been developed (or existing techniques) to analyze and demonstrate BIT/ETE FOMs. The remainder of this section discusses the techniques developed and how to implement them.

5.1 BIT/ETE FOM ANALYSIS TECHNIQUES

It is evident that in order to have a high confidence in the amount of BIT/ETE that has been designed into a system, a rigorous and detailed analysis must be performed. It has been determined that a majority of the BIT/ETE FOMs identified in Section 3 can be analyzed using either existing RMA FOM analysis methodologies or similar techniques. The analysis techniques developed (or existing) can be divided into three distinct groups:

1) rate (e.g. failure rate) dependent techniques
2) time dependent techniques
3) rate and time dependent techniques.

Table 15 summarizes the FOMs associated with each technique. The rate dependent technique applies to FOMs whose numerics can be determined solely by the ratio of rate of occurrences of some event(s) (e.g., failure rate tested divided by the total failure rate of a system can be used to express test thoroughness). FOMs that pertain to time dependent analysis techniques are FOMs that are strictly measured or determined through time synthesis (i.e., standard elemental maintenance time tables). Finally, the FOMs that are determined by a combination of the two previous techniques are FOMs that are measured through time synthesis, but are averaged by a rate of occurrence weighting.

Availability (A and $A_{B/E}$), BIT/ETE Reliability ($MTBF_{B/E}$), and Maintenance Personnel Skill Level (MPSL) are not included in Table 15. Availability and BIT/ETE Reliability can be analyzed using classical techniques and their definitions presented in Section 3.2. Due to the uniqueness of MPSL, it is discussed separately in Section 5.1.4. The analysis techniques applicable to each FOM are discussed in the following subsections.

TABLE 15. ANALYSIS TECHNIQUES AND THE BIT/ETE FOMs APPLICABLE TO THEM

Rate Dependent FOMs	Time Dependent FOMs	Rate/Time Dependent FOMs
FFD	T_B	T_{FD}
FFA	F_B	T_{FI}
FFSI		$MTTR_{B/E}$
TT		MTTR
FIR(L)		
FFI		
FEFI		

5.1.1 Rate Dependent Analysis Techniques

From the FOM definitions of Section 3.2, it is evident that Fractional Faults Detected (FFD), Fraction of False Alarms (FFA), Fraction of False Status Indications (FFSI), Test Thoroughness (TT), Fault Isolation Resolution (FIR(L)), Fraction of Faults Isolated (FFI), and Fraction of Erroneous Fault Isolation Results (FEFI) can be expressed as ratios. Typically the events being described are failures and the rate of occurrence is expressed as the failure rate. In the case of FFA and FFSI the occurrence rate includes items other than failures; however, for simplicity the following discussion will address only failure rate. Details on how the other rates (e.g. false alarm) are included in the analysis are described in the appropriate subsections.

Formulation of each respective ratio is accomplished by determining the failure rate associated with the numerator of the respective FOM definition (refer to Section 3.2) and dividing it by the failure rate associated with the denominator of the FOM.

The general form for analyzing BIT/ETE FOMs expressed as ratios is:

$$\text{ratio} = \frac{\sum_{i=1}^{N_c} \lambda_{n_i}}{\sum_{i=1}^{N_c} \lambda_{d_i}}$$

Where:

λ_{n_i} - failure rate of the i^{th} component associated with the numerator of the defined FOM

λ_{d_i} - failure rate of the i^{th} component associated with the denominator of the defined FOM

N_c - number of components in the system

The failure rate associated with the numerator and denominator of each ratio can be determined by summing up the associated failure rates. Summation of the failure rates is dependent upon the level of analysis. FOM analyses can be performed at any desired indenture level (e.g., component failure mode level, component level, functional level, unit level). It is clear that the most accurate results will be obtained for the analysis performed with the most detail (i.e. component failure mode level). For simplicity, the model presented is for the component level analysis. The models for the other levels can easily be obtained by slight modifications. Table 16 summarizes the various forms of the models that can be used for analyzing FOMs expressed as ratios. For the remainder of this report, only the models for the component level analysis will be presented.

The most difficult part of analyzing FOMs expressed as ratios is the determination of the corresponding numerator and denominator failure rates. AN FMEA (failure modes and effects analysis), along with the BIT/ETE test philosophy, can be used to facilitate the identification of these failure rates. The depth of the FMEA is dependent upon the analysis level selected. The following subsections discuss the application of the models developed to express FOMs as a ratio of failure rates for the associated FOMs.

5.1.1.1 Method of Analysis for Fraction of Faults Detected (FFD)

As stated in Section 3.2.2, FFD can be expressed two different ways; therefore, two models are presented here for the analysis of FFD. The models developed for FFD are:

- For FFD_A, (all faults):

$$FFD_A = \frac{\sum_{i=1}^{N_c} \lambda_{D_i}}{\sum_{i=1}^{N_c} \lambda_i}$$

- For FFD_D, (detected faults only):

$$FFD_D = \frac{\sum_{i=1}^{N_c} \lambda_{D_i}}{\sum_{i=1}^{N_c} (\lambda_i - \lambda_{UD_i})}$$

TABLE 16. SUMMARY OF THE OCCURRENCE RATE RATIO MODEL FORMS*

Analysis Level	Model	Parameters
Unit (or RI) Level	$\text{ratio} = \frac{\sum_{j=1}^{N_R} \lambda_{n_j}}{\sum_{j=1}^{N_R} \lambda_{d_j}}$	N_R - number of RIs in the system λ_{d_j} - Failure rate of the j^{th} unit (or RI) associated with the denominator of the FOM λ_{n_j} - Failure rate of the j^{th} unit (or RI) associated with the numerator of the FOM *Normally $(\lambda_{d_j} \geq \lambda_{n_j})$
Functional Level	$\text{ratio} = \frac{\sum_{k=1}^{N_F} \lambda_{n_k}}{\sum_{k=1}^{N_F} \lambda_{d_k}}$	N_F = number of functions contained in the system λ_{d_k} - Failure rate of the k^{th} function associated with the denominator of the FOM λ_{n_k} - Failure rate of the k^{th} function associated with the numerator of the FOM *Normally $(\lambda_{d_k} \geq \lambda_{n_k})$
Component Level	$\text{ratio} = \frac{\sum_{i=1}^{N_c} \lambda_{n_i}}{\sum_{i=1}^{N_c} \lambda_{d_i}}$	N_c - number of components contained in the system λ_{d_i} - Failure rate of the i^{th} component associated with the denominator of the FOM λ_{n_i} - Failure rate of the i^{th} component associated with the numerator of the FOM *Normally $(\lambda_{d_i} \geq \lambda_{n_i})$
Component Failure Mode Level	$\text{ratio} = \frac{\sum_{i=1}^{N_c} \sum_{q=1}^{N_i} \lambda_{n_{iq}}}{\sum_{i=1}^{N_c} \sum_{q=1}^{N_i} \lambda_{d_{iq}}}$	N_i - number of failure modes associated with the i^{th} component $\lambda_{d_{iq}}$ - Failure mode of the q^{th} failure mode of the i^{th} component associated with the denominator of the FOM. $\lambda_{n_{iq}}$ - Failure rate of the q^{th} failure mode of the i^{th} component associated with the numerator of the FOM.

NOTE: For simplicity the rates are expressed as failure rate.

where:

λ_i - The failure rate of the i^{th} component

λ_{D_i} - The failure rate of the i^{th} component that is detected by BIT/ETE

$$\lambda_{D_i} \leq \lambda_i \quad \text{for all } i$$

λ_{UD_i} - The failure rate of the i^{th} component that can be detected by any means

$$(\lambda_{D_i} + \lambda_{UD_i}) = \lambda_i \quad \text{for all } i$$

N_c - The number of components in the system/equipment.

Analysis of FFD requires a thorough understanding (down to the level of the analysis) of how the BIT/ETE will function and what the BIT/ETE can test. In conjunction with an FMEA, it can be determined whether the BIT/ETE can test and detect the various failure modes that will occur. The failure rate of any failure mode that can be tested and detected by BIT/ETE will comprise the numerator portion of the FFD failure rate ratio.

As mentioned previously, the level at which the analysis is performed will affect the accuracy of the analysis results. Undetected failures primarily occur at the component failure mode level, thus in order to analyze them accurately the analysis level should be at the failure mode level. For FFD, it is recommended that the analysis be performed at the component level or the component failure mode level in order to obtain accurate results.

5.1.1.2 Method of Analysis for Fraction of False Alarms (FFA)

Analysis of FFA for a system is a very difficult task (as was indicated by its evaluation score of Section 4). As noted earlier, three of the major causes of false alarms are: 1) BIT/ETE failures, 2) transients (noise), and 3) out-of-tolerance conditions. The difficulties that exist are in the analysis of false alarm conditions caused by transients (noise) and out-of-tolerance conditions.

In order to analyze transients, an analysis not common with current RMA analysis techniques must be performed. Analysis of transients consists of analyzing the system's performance (analytically) when transients are simulated at various points in the system and at the systems interfaces. This can be done with relative ease by the use of computer aided circuit analysis techniques. However, the problem arises in defining the scenario of transients to be analyzed (i.e., what are the expected transient conditions in terms of frequency, magnitude, duration, etc...).

Analysis of out-of-tolerance conditions requires an analysis similar to a worst case analysis. Computer aided circuit analysis techniques usually provide for worst case analysis. However, these programs usually analyze an output signal when <u>all</u> the components are at their maximum or minimum specified value. In order to perform out-of-tolerance analyses of this type, slight modifications must be made to the current computer aided circuit analysis programs available. These modifications consist of providing the computer program the capability to analyze circuits when a single component is out-of-tolerance or any combination of components taken together are out-of-tolerance. It should be noted here that out-of-tolerance conditions that result in false alarms are usually a sign of poor design. If out-of-tolerance conditions are analyzed using the method presented, then poor tolerance specifications will probably be weeded out before the system is fabricated. Thus, the use of out-of-tolerance analysis techniques will provide feedback to correct problems before they can occur. In the event that a computerized circuit analysis program is not available, the above analysis would be next to impossible except for a very simple equipment.

The previously mentioned analyses (transient and out-of-tolerance) are fine for determining which components promote false alarms, but the methods presented cannot aid the engineer in determining when or at what rate these false alarm conditions will occur. In order to do this, methods must be derived to determine the drift characteristics (and probabilities of) and the noise immunity characteristics (and probabilities of) of system components as well as transients caused by external sources. For this study no attempt has been made to determine these methods. For the time being, engineering judgment must be used until methods can be developed.

The analysis of FFA is dependent upon the system reliability philosophy (i.e., are BIT/ETE failures also considered system failures). If BIT/ETE failures are considered system failures, then FFA can be analyzed by:

$$FFA_1 = \frac{\delta + \gamma}{\sum_{i=1}^{N_c} \lambda_{D_i} + \delta + \gamma}$$

where:

λ_{D_i} - The BIT/ETE detectable failure rate of the i^{th} component (see 5.1.1.1)

δ - the rate at which out-of-tolerance conditions will occur

γ - the rate at which transients occur

N_c - number of components in the system

If BIT/ETE failures are independent of system failures, then FFA can be analyzed by the following model:

$$FFA_2 = \frac{\sum_{j=1}^{N_{BC}} \lambda_{BF_j} + \delta + \gamma}{\sum_{i=1}^{N_c} \lambda_{D_i} + \sum_{j=1}^{N_{BC}} \lambda_{BF_j} + \delta + \gamma}$$

where:

N_{BC} - the number of BIT/ETE dedicated components

λ_{BF_j} - failure rate of the j^{th} BIT/ETE component that results in a false alarm

NOTE: For the two models presented, the number of system components, N_c, is not equal since N_c for the second model does not include BIT/ETE dedicated components.
(i.e., N_c for model 1 is equal to $N_c + N_{BC}$ of model 2)

5.1.1.3 Method of Analysis for Fraction of False Status Indications (FFSI)

Since FFSI also includes FFA, the methods used to determine false alarms (Section 5.1.1.2) also apply when determining FFSI. The model for analyzing FFSI is:

$$FFSI = \frac{\sum_{i=1}^{N_c} \lambda_{UD_i} + \delta + \gamma}{\sum_{i=1}^{N_c} (\lambda_{D_i} + \lambda_{UD_i}) + \delta + \gamma}$$

where:

λ_{UD_i} - is the failure rate of the i^{th} component that cannot be detected by any means.

NOTE: $(\lambda_{D_i} + \lambda_{UD_i}) = \lambda_i$ for all i

Note that the model presented is for the case where BIT/ETE failures are considered system failures (analogous to FFA_1 in 5.1.1.2). If BIT/ETE failures are independent system failures, then the summations of λ_{BF_j} are included in the numerator and denominator, and the summations of λ_{D_i} and λ_{UD_i} are modified to exclude BIT/ETE components.

5.1.1.4 Method of Analysis for Test Thoroughness (TT)

As noted before, there are several ways to analyze the FOM TT. Using a ratio of failure rates is the most effective measure. The model for analyzing TT is:

$$TT = \frac{\sum_{i=1}^{N_c} \lambda_{T_i}}{\sum_{i=1}^{N_c} \lambda_i}$$

where:

N_c - number of components in the system

λ_i - failure rate of the i^{th} component

λ_{T_i} - failure rate of the i^{th} component that is "tested" by BIT/ETE. ($\lambda_{T_i} \leq \lambda_i$ for all i)

The actual usefulness of the TT FOM is largely dependent upon the level of analysis (as was true with FFD). The above model presents TT for the component analysis level, one of the more detailed analysis levels. The analysis of TT can be performed at higher levels, such as the functional level and the equipment level. However, the accuracy of the FOM goes down as the analysis level gets higher. This is due to the assumptions made when a function is considered tested. That is, when a function is classified as "tested" by BIT/ETE, the assumption made is that the entire function (i.e., all components, thus the entire failure rate) is tested. Using these assumptions will give inaccuracies in the measure of TT.

The numerator of the model for TT consists of the failure rate "tested" by BIT/ETE. There is a great deal of uncertainty as to what "tested" means. The definition of tested is dependent upon the level that the analysis is performed on. The most general definition for tested is:

"Tested" - The portion of the equipment that is monitored by BIT/ETE.

If the analysis is performed on the component failure mode level, then it is safe to say that the failure rate of the components tested (or monitored) is also the failure rate of the faults detectable by BIT/ETE. However, for any higher level of analysis, the failure rate tested is merely the failure rate of the functions or equipments that are monitored by BIT/ETE.

TT can also be measured without using failure rates. Instead of using failure rate, TT can be measured as a ratio of something other than failure rate such as the number signals tested relative to the total number of signals. This method, and methods similar to it, (i.e., number of functions tested, number of units tested, etc...) is by far the most inaccurate measure since it does not account for the relative frequency of failure occurrences.

5.1.1.5 Analysis Method for Fault Isolation Resolution (FIR(L))

Analysis of FIR(L) can also be accomplished by using a ratio of failure rates. For this case, there will be a set of ratios used due to the way FIR(L) is defined. Thus given FIR(L) expressed as:

$FIR(L_1) = P_1$

$FIR(L_2) = P_2$

$FIR(L_3) = P_3$

where $P_1 < P_2 < P_3 \leq 1$

then the model for analyzing $FIR(L_k)$ is:

$$FIR(L_k) \text{ is: } \frac{\sum_{j=1}^{N_R} \lambda_{LK_j}}{\sum_{j=1}^{N_R} (\lambda_j - \lambda_{UD_j})} \quad \text{for } k = 1, 2, 3$$

where: N_R - the number of RIs in the system

λ_{LK_j} - failure rate of the j^{th} RI associated with the L_k fault isolation resolution level

$$\lambda_{LK_j} \leq (\lambda_j - \lambda_{UD_j}) \text{ for all } j$$

λ_j - failure rate of the j^{th} RI

λ_{UD_j} - failure rate of the j^{th} RI that is undetectable by any means

In order to determine the values for the above model, thorough knowledge of the BIT/ETE fault isolation test philosophy is required. Not only does this require information on the BIT/ETE test capabilities and the test circuitry, it also requires a thorough understanding on how the tests are documented (e.g., software documentation and maintenance manuals documentation), since FIR(L) is normally dependent upon human interaction.

5.1.1.6 Analysis Method for Fraction of Faults Isolated (FFI)

As noted in Section 3.2.10 FFI is greater than or equal to $FIR(L_k)$, where L_k is for the maximum specified fault isolation group size. That is

$$FFI \geq FIR(L_k)$$

where:

L_k = maximum specified fault isolation group size

FFI can be expressed as:

$$FFI = \frac{\sum_{i=1}^{N_C} \lambda_{I_i}}{\sum_{i=1}^{N_C} \lambda_i}$$

where:

N_C - number of components

λ_i - failure rate of the i^{th} component

λ_{I_i} - failure rate of i^{th} component that is isolated by BIT/ETE

Determination of the failure rate associated with the numerator and denominator of FFI requires the same information as is required for FIR(L) (refer to Section 5.1.1.5). However, for FFI knowledge of the fault isolation group sizes (i.e., fault isolation ambiguity) is not necessary.

5.1.1.7 Analysis Method for Fraction of Erroneous Fault Isolation Results (FEFI)

FEFI was defined as the fraction of erroneous fault isolation results. Because of the definition, FEFI cannot be analyzed until the system or equipment is operable or the BIT/ETE fault isolation function is operable. Thus, FEFI can only be determined through testing.

The major reason for the inability to analyze FEFI is due to the philosophy of hardware design. The fault isolation test routines are usually written assuming that they are correct. Thus, it is not possible to determine whether a fault isolation result is erroneous until actual testing is performed on it. However, there is one possibility of analyzing FEFI before testing. If the test routines are thoroughly defined, then with the aid of an FMEA, the effect due to a single failure can be analyzed and erroneous fault isolation results may be flagged out before they occur. This is a very tedious task and it is unlikely that a task of this type will be performed.

5.1.2 Time Dependent FOMs

F_B and T_B are BIT/ETE FOMs that are dependent on time only. Thus, the analysis of these FOMs requires only a time line analysis. Time line analysis consists of the measurement of a sequence of events using one of the following methods of measurement:

1. actual time measurements (i.e., time study)
2. tables of standard elemental times
3. engineering judgment (or analysis)

Time line analysis using actual time measurements consists of measuring (with a stopwatch or something similar) how long it takes to perform a sequence of events. Time line analysis using standard elemental time consists of reconstructing a sequence of events using standard times (e.g., MIL-HDBK-472, RADC-TR-70-89, or RADC-TR-78-169) for the various actions that comprise the sequence of events. The final method for measuring the time required to perform a sequence of events is to use engineering judgment or analysis to analytically determine how long it takes to perform the tasks.

To perform a time line analysis, the following steps are required:

1. identification of the sequence of events that are to be measured
2. determination of the time required to perform each unique step using one of the three methods presented
3. determination of the time to perform the identified sequence of events

Identification of the sequence of events that are to be measured is the most important step. If the proper actions required are not identified correctly, then the time line analysis is invalid.

The following subsections discuss the application of the time line analysis technique for the associated FOMs.

5.1.2.1 Analysis Method for Frequency of BIT/ETE Executions (F_B)

Since most periodic BIT/ETE test routines are normally computer controlled, F_B can be determined with respect to the clock rate of the computer CPU (Central Processing Unit), that controls the test.

As noted in the definition of F_B, F_B is defined as:

MIN (F_{B_i}) or MAX (T_{cycle_i}) for all i

where:

F_{B_i} - cycling rate of the i^{th} continuous BIT/ETE test routine

T_{cycle_i} - the cycling time ($= F_{B_i}^{-1}$) of the i^{th} continuous BIT/ETE test routine

Measurement of each cycle time, T_{cycle_i}, can be determined analytically by:

$$T_{cycle_i} = \frac{\text{(the number of CPU clock cycles between starts of the } i^{th} \text{ BIT/ETE test routine)}}{\text{(CPU clock rate)}}$$

Thus, the frequency of execution of the i^{th} BIT/ETE test routine is:

$$F_{B_i} = (T_{cycle_i})^{-1}$$

5.1.2.2 Analysis Method for Mean BIT/ETE Running Time (T_B)

As stated in the definition of T_B (Section 3.2.6), there are several definitions for T_B. Once the definition of T_B has been determined (i.e., for what tests, with or without a fault, etc...) analysis of the mean BIT/ETE running time is accomplished by using the following model:

$$T_B = \frac{\sum_{i=1}^{N_B} T_{B_i}}{N_B}$$

where:

N_B - the number of BIT/ETE test routines included in T_B

T_{B_i} - the running time for the i^{th} BIT/ETE test routine

T_{B_i} is determined by the following:

$$T_{B_i} = \frac{\text{(number of instruction steps cycled by the } i^{th} \text{ BIT/ETE test routine)}}{\text{(computer instruction cycling rate)}}$$

The number of instruction steps cycled is dependent upon the definition of T_B. For example, if T_B were defined for "with a fault found" and the BIT/ETE test routines were organized such that the test "loops on an error" until a certain threshold level has been obtained, then each T_{B_i} must account for the reiteration of the test steps that are in the loop.

5.1.3 Failure Rate and Time Dependent FOMs

FOMs that are failure rate and time dependent (i.e., T_{FD}, T_{FI}, MTTR, $MTTR_{B/E}$) are normally FOMs whose time average is dependent upon the rate of occurrence (i.e., failure rate). These FOMs can be analyzed using current analysis techniques similar to MIL-HDBK-472, procedure 2 and RADC-TR-78-169, a failure rate weighted average of times.

As was true for the failure rate dependent FOMs (Section 5.1.1) these FOMs can also be analyzed at various levels (i.e., equipment, unit, component, etc.). The general model for analyzing FOMs of this type is very similar to the models of Table 16. With slight modification of the models in Section 5.1.1, the general model for a component level analysis can be expressed as:

$$\text{average time} = \frac{\sum_{i=1}^{N_C} \lambda_i \times (t_i, \text{ the time for the } i^{th} \text{ component})}{\sum_{i=1}^{N_C} \lambda_i}$$

where:

t_i - is the time to perform the action defined by the FOM for the i^{th} component. (t_i is determined by time line analysis)

λ_i - failure rate of the i^{th} component

The same philosophy holds true for failure rate and time dependent FOMs as did for the failure rate dependent FOMs. The accuracy of the analysis is dependent upon the level at which the analysis is performed.

Straight methods for determining MTTR and $MTTR_{B/E}$ are readily available (e.g., MIL-HDBK-472 and RADC-TR-78-169) and require no further discussion here. These same techniques are also applicable to T_{FD} and T_{FI}, differing only in the representation of the synthesized time, t_i. For Mean Fault Detection Time, T_{FD}, each t_i represents the time necessary to detect and indicate a fault in the i^{th} component. For the Mean Fault Isolation Time, T_{FI}, t_i represents the time necessary to perform the fault isolation process for a fault in the i^{th} component.

The subdivision of the failure rate for the numerator and denominator of the defined FOM is done the same way it is done for the failure rate dependent FOMs (refer to Section 5.1.1).

5.1.4 Analysis Method for Maintenance Personnel Skill Level (MPSL)

Analysis of MPSL is dependent upon the way it has been defined. As noted in Section 3.2.12, MPSL can be defined as an average or a minimum. In most cases, it is defined as a minimum since it will usually denote the skill level that will maintain the system. Analysis methods for both definitions are presented here.

If MPSL is defined as the minimum skill level required to maintain a system, then the following model holds true.

$$MPSL = MIN\ (MPSL_i) \quad \text{for all } i$$

where:

$MPSL_i$ - the skill level required to perform maintenance for the i^{th} failure

Normally if MPSL is defined as a minimum, it will also have a threshold level specified with it (e.g., ϕ percent of all faults will be maintainable by a specified skill level). If this is true, then MPSL can be analyzed as follows:

$$\frac{\sum_{i=1}^{N_C} \lambda_{SL_i}}{\sum_{i=1}^{N_C} \lambda_i} \times 100 \geq \phi^*$$

where:

λ_{SL_i} - failure rate of the i^{th} component that is maintainable by a skill level less than as equal to the specified minimum

*In order to satisfy the requirements imposed this relationship must be true.

If MPSL is defined as the average skill level required to perform maintenance, then MPSL can be represented by:

$$MPSL = \frac{\sum_{i=1}^{N_C} \lambda_i \times (MPSL_i)}{\sum_{i=1}^{N_C} \lambda_i}$$

Note that MPSL must be of some linear form (e.g., 1 to 5).

5.2 FORMAL DEMONSTRATION OF FOMS

One way to assess the degree to which certain FOM requirements have been met is through a formal demonstration test. Such a test is usually of a statistical nature, i.e., certain random quantities containing information about the true value of the FOM under consideration are observed and evaluated (for example, total number of failures in a given test time for a reliability demonstration test).

Formal demonstration tests already exist for the FOMs $MTBF_{B/E}$, $MTTR_{B/E}$, and MTTR, and are described in military standards (MIL-STD-471 and MIL-STD-781). These standards also apply to A and $A_{B/E}$ indirectly. Formal demonstration tests for FFD, FFI, FEFI, and FIR are described in Sections 5.2.1 and 5.2.2 The remaining FOMs (i.e., FFA, FFSI, T_{FD}, T_B, F_B, T_{FI}, and MPSL) do not lend themselves to statistical demonstration procedures and must be assessed using analytical means or on the basis of field data (for a discussion of these concepts, see Section 5.3).

5.2.1 Demonstration of Certain FOMs Expressed as Fractions

5.2.1.1 Mathematical Discussion

It is clear from the analytical definitions of FFD, FFI and FEFI that these FOMs may be interpreted as probabilities that certain events occur. It is, thus, appropriate to develop demonstration test plans for these FOMs based on the binomial distribution. Statistical demonstration tests based on the binomial distribution will be developed in this section. The applicability of these methods to specific FOMs (FFD, FFI, and FEFI) will be discussed and illustrated with examples in the next four sections.

Denote by S_n a random variable (also referred to as a test statistic) which has a binomial distribution with parameters n (a positive integer) and p (the probability of "success"). That is,

$$P\{S_n = k\} = \binom{n}{k} p^k (1-p)^{n-k} \qquad (5.2.1.1.1)$$

for $k = 0, 1, \ldots, n$. For fixed n, the procedure for testing the simple hypothesis (H_o) $p = p_o$ against the simple alternative (H_1) $p = p_1$, $p_1 < p_o$ is to

Reject H_o if $S_n \leq k$ (hence accept H_1)*

Accept H_o if $S_n \geq k + 1$ (hence reject H_1).

(The number k is called the accept/reject criterion). Here p_o may be thought of as the "design goal" or specified value of the FOM under consideration, and p_1

is the "Minimum acceptable" value of the FOM under consideration. It has been tacitly assumed here that values of the FOM closer to 1.0 are the more desirable values. Therefore, in particular, we will be demonstrating 1-FEFI instead of FEFI. The parameter "n" is the sample size on which the test statistic S_n is based. The statistic S_n is the total number of "successes" in n independent experiments. For example, for FFD n sample faults would be inserted or simulated in the equipment undergoing demonstration testing. In this case, S_n would be the number of the n sample faults subsequently detected with BIT/ETE. The statistic S_n will thus have a binomial distribution given by equation (5.2.1.1.1) with p equal to the actual probability of fault detection, i.e., the actual value of the FOM FFD. The value k in (*) is determined for a given n and p_o by selecting the producer risk α, or, equivalently, k is determined for fixed n and p_1, by selecting the consumer risk β. The value α is the probability that the demonstration test is failed given that the design goal has actually been met. The value β is the probability that the demonstration test is passed given that only the minimum acceptable has been achieved. Mathematically,

$$\alpha = \sum_{i=o}^{k} \binom{n}{i} p_o^i (1-p_o)^{n-i} \quad (5.2.1.1.2)$$

$$\beta = \sum_{i=k+1}^{n} \binom{n}{i} p_1^i (1-p_1)^{n-i} \quad (5.2.1.1.3)$$

Since (5.2.1.1.1) defines a discrete probability distribution function, preselected values of α and β will not exactly be achievable. However, (5.2.1.1.3) or (5.2.1.1.2) will determine a value of k which provides a consumer or producer risk closest to the preselected values of consumer and producer risk, respectively. It can be shown (reference 3) that the hypothesis test (*) is optimal in the sense that for a fixed value of α, the resulting k yields the smallest possible β and vice versa.

To aid in the design of demonstration tests, Appendix A contains listings of the exact probability (using the binomial distribution) of accepting H_o (i.e., passing the test) as a function of the true value of p for fixed pairs of n and k. The values n = 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100 were chosen along with (for each n) k = 0.80n, 0.80n + 1, ..., n-1. Denoting by $\gamma(p)$ the probability of accepting H_o as a function of the true value of p (i.e., $\gamma(p)$ represents the entry in Appendix A corresponding to the probability of passing the test), the exact values of α and β may be read directly (or interpolated) from the tables for fixed (n, k), by

$$\alpha = 1 - (p_o), \quad \beta = \gamma(p_1). \qquad (5.2.1.1.4)$$

The use of Appendix A will be illustrated for designing test plans for the FOMs FFD, FFI, and FEFI in the next sections. Often, specific values for p_o, p_1, α and β will be chosen and it will, thus, be necessary fo find the sample size n and the pass/fail value k necessary to complete the definition of the demonstration test. This could be accomplished by searching the table for the desired combination (n, k) which would yield $\alpha \approx 1 - \gamma(p_o)$ and $\beta \approx \gamma(p_1)$. A more efficient method (though only approximate in nature) relies on using the normal distribution approximation to the binomial distribution (reference 3). Denoting by Z_t the t^{th} quantile of the standard normal distribution (e.g., $Z_{0.95} = 1.645$) the approximate value of n and k for a given set of values p_o, p_1, α, β are given by (see reference 1),

$$n \cong \left\{\frac{Z_{1-\beta}\sqrt{p_1(1-p_1)} - Z_{\alpha}\sqrt{p_o(1-p_o)}}{(p_o-p_1)^2}\right\}^2 \qquad (5.2.1.1.6)$$

and

$$k \cong np_1 + Z_{1-\beta}\sqrt{np_1(1-p_1)}. \qquad (5.2.1.1.7)$$

It should be emphasized that these values on n and k are approximations. Having computed n and k from (5.2.1.1.6) and (5.2.1.1.7), this pair (n, k) can be used as a "starting point" in searching table 5.2.1.1.1 for better value of n and k (i.e., better in sense that they, in conjunction with the desired values p_o and p_1 yield values of producer and consumer risk closer to the preselected values α and β, respectively.

Appendix A.2 gives step-by-step procedures for determining demonstration tests using the tables in Appendix A. Two important cases are covered: in case 1, n, p_1 and β are known and p_o, k are to be determined assuming $\alpha = \beta$; in case2, β, p_1, α, and p_o are known and n, k are to be determined.

5.2.1.2 Demonstration of Eraction of Faults Detected (FFD)

As seen in Section 3.2, FFD can be either: 1) the probability that any fault is detected by BIT/ETE or 2) the probability that any detected fault is detected by BIT/ETE. In either case, it will be necessary (for statistical demonstration procedures) to insert or simulate a number (say N) of faults at random in the system undergoing demonstration testing. These faults should be distributed in a manner such that, on the average, portions of the equipment possessing higher percentages of the total failure rate will possess a proportionately high percentage of the total number N of faults (see Section 5.4 for further discussion of fault seeding). In either case (case 1 or 2), the test statistic S_n will be the total number of the N "seeded" faults detected with BIT/ETE. In case 1, the sample size n will simply be N. However, in case 2, if j of the seeded faults are not detectable by any means, then the sample size n will be N-j.

In general, the magnitude of n will depend on the minimum acceptable value of FFD (p_1), the consumer risk (β), the design capabilities (possible values of p_o), and the producer risk (α). For example, for values of p_o and p_1 very close together, large values of n will be necessary for reasonable risks α and β. Also, if p_1, β_1, and n are fixed, it may not be possible to design a value p_o high enough to allow for a reasonable value of α (see example 1). Therefore, care should be taken in designing a demonstration test for FFD (and the other FOMs in this section) such that reasonable levels of risks α and β are possible. Often, from specifications, it will be known ahead of time what the rough values of α, β, p_o, and p_1 will be. In this case, (5.2.1.1.6) and (5.2.1.1.7) can be used to determine approximate values of n (sample size) and k (pass/fail criterion) and then Appendix A can be used to "zero in" more on a combination of n and k which yields exact consumer and producer risks closer to the preselected α and β.

The preceding concepts are illustrated below with three examples. These examples also serve, with minor modification, to illustrate the demonstration of FFI and FEFI.

Example 1. The consumer specifies his risks as $\beta = 0.95$ and the minimum acceptable value of FFD (for all faults) as $p_1 = 0.98$. The consumer further specifies that the demonstration test will be based upon a sample size of $N = n = 45$ faults (see Appendix A.2, case 1). This is sufficient information to determine the accept/reject criterion (or simply "test criterion") k. Searching Appendix A with $n = 45$ and $p_1 = 0.98$ for various values of k, it is found that the smallest possible value of β (with $n = 45$, $p_1 = 0.98$) is 0.4029 for $k = 44$. Supposing that $\beta = 0.4029$ instead of 0.05 is acceptable, let us determine what the design goal p_0 must be. Scanning the table with $n = 45$, $k = 44$, it is seen that p_0 must be larger than 0.995 to achieve an α level less than 0.20 (i.e., it is seen that $1 - \gamma(9.995) = 0.20$). If $\alpha = 0.20$ is acceptable to the producer, and if $p_0 = 0.995$ is a realistic design goal, then the test which most closely matches the original specifications of the consumer is:

Producer passes (H_0 accepted) if

# of faults detected $\equiv S_{45} \geq k+1 = 45$

Producer fails (H_1 accepted) if

# of faults detected $\equiv S_{45} \leq 44$

The exact values of α and β for this test are 0.20 and 0.4029, respectively. Notice that not only was it impossible to achieve an exact β closer than 0.4029 to 0.05 (for $n = 45$, $p_1 = 0.98$), but the test criterion implies that all 45 faults must be detected in order to pass the test. Thus, although the test (i.e., that all 45 faults be detected in order for the producer to pass) seems very strict, the β level indicates excessive risk on the part of the consumer.

Example 2. The consumer specifies his risk as $\beta = 0.10$ and the minimum acceptable value of FFD (for all faults) as 0.945. He further specifies that the demonstration test will be based upon a sample of size $N = n = 70$ (see Appendix A.2, case 1). Looking in Appendix A, it is seen that for the case $n = 70$, $k = 68$, $\gamma(0.945) = 0.0967$ which is the exact β. Thus, the demonstration test is

Producer passes (H_0 accepted) if

# of faults detected $\equiv S_{70} \geq k+1 = 69$

Producer fails (H_1 accepted) if

# of faults detected $\equiv S_{70} \leq 68$

Since p_0 has not been specified here, the producer must examine the table for $n = 68$ to find the value p_0 to which he can design in order to achieve his desired level of risk, α. If $\alpha = 0.10$ is acceptable, it is seen from the table (for n = 70, k = 68) that $1 - \gamma(0.99) = 0.1553$ and $1 - \gamma(0.995) = 0.0483$. Simple linear interpolation yields $p_o = 0.9926$ as the design goal for FFD.

Example 3. Assume $\alpha = \beta = 0.10$, $p_1 = 0.80$, $p_o = 0.90$ (see Appendix A.2, case 2). To complete the definition of a demonstration test, n and k must be determined. From 5.2.1.1.6 and 5.2.1.1.7 it is seen that (since $Z_{0.10} = -1.282 = -Z_{0.90}$)

$$n \cong \frac{\left(1.282\sqrt{(0.80)(0.20)} + 1.282\sqrt{(0.90)(0.10)}\right)^2}{(0.90-0.80)^2}$$

$$\cong 81$$

and

$$k \cong (81)(0.80) + 1.282\sqrt{(81)(0.80)(0.20)}$$

$$\cong 69$$

The case n = 81 was not included in Appendix A but considering the cases in Table 5.2.1.1 for n = 80, it is seen that for n = 80, k = 68, $\alpha = 1 - \gamma(0.90) = 0.1004$ and $\beta = \gamma(0.80) = 0.1006$. Thus, since these exact values are extremely close to the preselected values of $\alpha = \beta = 0.10$, the test is thus:

Producer passes (H_o accepted) if

# of faults detected $= S_{80} \geq k+1 = 69$

Producer fails (H_1 accepted) if

# of faults detected $= S_{80} \leq 68$.

From this example it is seen that equations 5.2.1.1.6 and 5.2.1.1.7 can yield values of n and k which in turn yield values of α and β quite close to the preselected values of α and β. In this example, however, the value of n computed in 5.2.1.1.6 satisfied

$$np^* \geq 5 \qquad (5.2.1.2.1)$$

where

$$p^* = \min\left\{p_o,\ 1-p_o,\ p_1,\ 1-p_1\right\}.$$

It can be shown (reference 3) that condition 5.2.1.2.1 is sufficient for the normal distribution approximation used in the derivation of 5.2.1.1.6 and 5.2.1.1.7 to be a good approximation. Values of n and k computed from 5.2.1.1.6 and 5.2.1.1.7

which do not satisfy 5.2.1.2.1 cannot be expected to be reliable. However, such values will still provide a starting point for determining values n and k which are acceptable.

5.2.1.2 Demonstration of Fraction of Faults Isolated FFI

To demonstrate FFI, N faults are inserted or simulated randomly in the system undergoing the demonstration test. The sample size n (see Section 5.2.1.1) is N-j where j is the number of the N faults which are not detectable by any means. The test statistic S_n is simply the number of the N-j BIT detected faults which are isolated to the replacement level specified by the maintenance concept. See Section 5.2.1.2 for examples of how to design specific demonstration tests. If random faults occur in addition to the seeded faults, the sample size is adjusted accordingly (see Section 5.2.1.2, for example).

5.2.1.3 Demonstration of Fraction of Erroneous Fault Isolation (FEFI) Results

Since FEFI is the probability of erroneous fault isolation, it will be more convenient to demonstrate 1-FEFI. To accomplish this, N faults are inserted or simulated randomly in the system undergoing the demonstration test. The sample size n (see Section 5.2.1.1) is N-i where i is the number of the N seeded faults which cannot be detected by BIT. The test statistic S_n is then the number of the N-i faults which are correctly isolated by BIT. See Section 5.2.1.2 for examples of how to design specific demonstration tests. If random faults occur, in addition to the N seeded faults, the sample size n = N-i is adjusted by adding in the number of additional random faults detected by BIT.

5.2.2 <u>Demonstration Tests for Fault Isolation Resolution (FIR(L))</u>

The FOM FIR(L) may be interpreted as the probability that a fault (detected by BIT) will be isolated by BIT to L or less replaceable items (RIs) (FIR(L)) is a generalization of FFI). This FOM is often specified at more than one level L. That is, there may be k levels $L_1 < L_2 < \ldots < L_k$ with corresponding specified values $(FIR(L_1) < FIR(L_2) < \ldots < FIR(L_k)$. Equivalently, the probabilities

$$
\begin{aligned}
p_1 &= FIR(L_1) \\
p_2 &= FIR(L_2) - FIR(L_1) \qquad (5.2.2.1) \\
&\vdots \\
p_k &= FIR(L_k) - FIR(L_{k-1})
\end{aligned}
$$

may be specified. It is obvious from (5.2.2.1) that a given set of $p_1, \ldots, p_k$ will uniquely determine FIR (L_1), FIR (L_2), ..., FIR (L_k) and conversely. The probabilities $p_1, \ldots, p_k$ are thus interpreted as:

p_1 = the probability of isolating a fault to $\leq L_1$ RIs

p_2 = the probability of isolating a fault to $> L_1$ RIs and $\leq L_2$ RIs.

•
•
•

p_k = the probability of isolating a fault to $> L_{k-1}$ RIs and $\leq L_k$ RIs.

Therefore, $p_1, \ldots p_k$ are probabilities of k mutually exclusive events. By analogy with the demonstration tests of the last section based on the binomial distribution, the demonstration tests for fault isolation resolution will be based on the multinomial distribution.

If there are a total of N_R RIs in the system under consideration, then it will be convenient to take $L_k = N_R$ so that FIR (L_k) will always be 1. In this case,

$$\sum_{i=1}^{k} p_i = \text{FIR}(L_k) = 1. \qquad (5.2.2.2)$$

To design a demonstration test for fault isolation resolution, it will be necessary to know both the minimum acceptable and design goal values for the vector of probabilities $\bar{p} = (p_1, \ldots, p_k)$.

The demonstration test statistic is defined as follows: Insert or simulate N faults at random into the system undergoing demonstration testing and suppose that n ($n \leq N$) of these faults are detected by BIT. Let:

X_1 = the number of the n faults detected by BIT which are isolated by BIT to $\leq L_1$ RIs

X_2 = the number of the n faults detected by BIT which are isolated by BIT to $> L_1$ RIs and $\leq L_2$ RIs

•
•
•

X_k = the number of the n faults detected by BIT which are isolated by BIT $> L_{k-1}$ RIs and $\leq L_k$ RIs.

Then the test statistic is defined by

$$T = \sum_{i=1}^{k} X_i \ln(p_i'/p_i^*) = \sum_{i=1}^{k-1} A_i X_i + n \ln(p_k'/p_k^*) \quad (5.2.2.3)$$

where

$$A_i = \ln(p_i'/p_i^*) - \ln(p_k'/p_k^*), \; i=1, 2, \ldots, k-1, \quad (5.2.2.4)$$

with $p'_1, \ldots, p'_k$ denoting the design goal values for the vector of probabilities $\bar{p}$, and $p_1^*, \ldots p_k^*$ denoting the minimum acceptable values for the vector of probabilities $\bar{p}$. The test statistic defined by Eq. 2.2.3 follows from the usual likelihood ratio test for testing the simple hypothesis (H_0) that $\bar{p} = (p_1', \ldots, p_k')$ against the simple alternative (H_1) that $\bar{p} = (p_1^*, \ldots, p_k^*)$ and the test based on 5.2.2.3 is optimal in the sense discussed in Section 5.2.2.1 (reference 3). The demonstration test is then

$$\begin{aligned} &\text{Producer fails test if } T < C \\ &\text{Producer passes test if } T \geq C \end{aligned} \quad (5.2.2.5)$$

Where C, the pass/fail criterion, is determined by selecting either the producer risk α or the consumer risk β (but not both simultaneously). Since the random vector $(X_1 \ldots, X_k)$ has a multinomial distribution under either hypothesis, that is, for non-negative integers

$$x_1, \ldots, x_k \text{ with } \sum_{i=1}^{k} x_i = n;$$

$$P\{X_1 = x_1, \ldots, X_k = x_k\} = \frac{n!}{\left(\prod_{i=1}^{k} x_i!\right)} \cdot \prod_{i=1}^{k} p_i^{x_i} \quad (5.2.2.6)$$

Where $p_i = p_i'$ ($i = 1, 2, \ldots, k$) under H_0 and $p_i = p_i^*$ ($i = 1, 2, \ldots, k$) under H_1, the value C is determined by either one of the following equations:

$$\alpha = \sum_{A} \left\{ \frac{n!}{\prod_{i=1}^{k} x_i!} \cdot \prod_{i=1}^{k} p_i'^{x_i} \right\} \quad (5.2.2.7)$$

$$\beta = \sum_{B} \left\{ \frac{n!}{\prod_{i=1}^{k} x_i!} \cdot \prod_{i=1}^{k} p_i^{* x_i} \right\} \quad (5.2.2.8)$$

where: A is the set of all vectors of non-negative integers $(x_1, \ldots, x_k)$ such that

$\sum_{i=1}^{k} x_i = n$ and $T < C$; B is the set of all vectors of non-

negative integers $(x_1, \ldots, x_k)$ such that $\sum_{i=1}^{k} x_i = n$ and $T \geq C$.

As with the binomial case discussed in Section 5.2.1.1, exact prespecified values of α or β will not be attainable due to the discreteness of the multinomial distribution. However, a value of C can be determined from 5.2.2.7 or 5.2.2.8 which yields an exact value of α or β closest to the prespecified value.

Since the sample size n for a demonstration test of fault isolation resolution will often be large, the pass fail value C can be determined using normal distribution approximations. Denoting by Z_t as the t^{th} quantile of the standard normal distribution (e.g., $Z_{0.90} = 1.282$) and utilizing the normal approximation in (5.2.2.8) the value of C is approximately

$$C = C_o + n \ln (p_k'/p_k^*) \qquad (5.2.2.9)$$

where

$$C_o = n \sum_{i=1}^{k-1} A_i p_i^* + Z_{1-\beta}\sqrt{n\left[\sum_{i=1}^{k-1} A_i^2 p_i^*(1-p_i^*) - \sum\sum_{1 \leq i < j \leq k-1} 2 A_i A_j p_i^* p_j^*\right]} \qquad (5.2.2.10)$$

Generally, conditions (5.2.2.7) and (5.2.2.8) will not be satisfied simultaneously for a given value of n. However, when n is presumed to be large, the normal approximation may be applied to both (5.2.2.7) and (5.2.2.8) to yield the value of n necessary to satisfy (5.2.2.7) and (5.2.2.8) simultaneously. The required value of n is approximately

$$n \cong (Z_{1-\beta}\, \sigma^* - Z_\alpha \sigma')^2/(\mu^* - \mu')^2 \qquad (5.2.2.11)$$

where

$$\mu' = \sum_{i=1}^{k-1} A_i p_i' \qquad (5.2.2.12)$$

$$\mu^* = \sum_{i=1}^{k-1} A_i p_i^* \qquad (5.2.2.13)$$

$$\sigma' = \sqrt{\sum_{i=1}^{k-1} A_i^2 p_i'(1-p_i') - 2 \sum\sum_{1 \le i < j \le k-1} A_i A_j p_i' p_j'} \qquad (5.2.2.14)$$

$$\sigma^* = \sqrt{\sum_{i=1}^{k-1} A_i^2 p_i^*(1-p_i^*) - 2 \sum\sum_{1 \le i < j \le k-1} A_i A_j p_i^* p_j^*} \qquad (5.2.2.15)$$

The results (5.2.2.9) through (5.2.2.10) are discussed and derived in reference 1.

These results will now be illustrated by some examples. Appendix B contains several demonstration test plans for various sample sizes and design goal and minimum acceptable values for $\bar{p}$ for the case $k = 3$ (i.e., two actual levels of fault isolation resolution, the third being $L_3 = N_R$). In Appendix B the pass/fail value C was computed using (5.2.2.10) for the prespecified value of β. Then exact values of α and β were computed using (5.2.2.7) and (5.2.2.8) for the C value computed from (5.2.2.10). It can be seen that the approximation (5.2.2.10) is very good for the sample sizes considered and the $\bar{p}$ values considered.

Example: Suppose there are two levels (i.e., $k = 3$) of fault isolation resolution under consideration. Specifically, the levels L_1, L_2 and the minimum acceptable and design goal values for FIR (L_1) and FIR (L_2) are:

$L_1 = 1$, $L_2 = 3$ ($L_3 = N_R$)

Design Goal: FIR (1) = 0.800 or $p_1' = 0.80$
FIR (3) = 0.900 or $p_2' = 0.10$
FIR (L_3) = 1.000 or $p_3' = 0.10$

Minimum
Acceptable: FIR (1) = 0.700 or $p_1^* = 0.70$
FIR (3) = 0.875 or $p_2^* = 0.175$
FIR (L_3) = 1.000 or $p_3^* = 0.125$

Suppose further that the consumer risk β is prespecified as 0.10. If n faults are detected by BIT (out of the original N inserted or simulated faults) then let

X_1 = the number of the n faults isolated by BIT to 1 RI
X_2 = the number of the n faults isolated by BIT to > 1 RI and ≤ 3 RIs
X_3 = the number of the n faults isolated by BIT to > 3 RIs and ≤ L_3 RIs.

From Table B-5 of Appendix B (or using (5.2.2.1), (5.2.2.3) and (5.2.2.4)) it is seen that:

$$T = 0.13353\, X_1 \quad -0.55962\, X_2 \quad -0.22314\, X_3.$$

Again from the Table, it is seen that for n = 50, the exact value of β is 0.0889 and the exact value of the producer risk α is 0.3557. The pass/fail value C is 0.8226, so that the producer passes the test (when n = 50) if T ≥ 0.8226 and fails otherwise. If the value 0.3557 is too large for α, then a larger sample size n will be required. If α = 0.10 is desired, then the required n may be approximated using (5.2.2.11). The calculation is:

$$n \cong (1.282\,\sigma^* + 1.282\,\sigma')^2 / (\mu^* - \mu')^2$$

where

$$\mu' = (0.13353)\,(0.80) - (0.55962)\,(0.10) = 0.05086$$
$$\mu^* = (0.13353)\,(0.70) - (0.55962)\,(0.175) = -0.00446$$

$$\sigma' = [(0.13353)^2\,(0.80)\,(0.20) + (0.55962)^2\,(0.10)\,(0.90) + 2(0.13353)(0.55962)(0.80)(0.10)]^{1/2} = 0.20735$$

$$\sigma^* = [(0.13353)^2(0.70)(0.30) + (0.55962)^2\,(0.175)\,(0.825) + 2(0.13353)(0.55962)(0.70)(0.175)]^{1/2} = 0.25936$$

or

$$n = 117$$

The value n = 117 is not included in the Table but for n = 110, α = 0.1051 and β = 0.0910. Since these values are very close to 0.10 the test for n = 110 may be used. For the case n = 110, the pass/fail value C is 0.0606 and the producer passes if T $\geq$ 0.0606 and fails otherwise. Suppose that:

$X_1 = 84$
$X_2 = 11$
$X_3 = 15$

is observed in the test with n = 110.

Then, T = (0.13353) (84) - 0.55962(11) - 0.22314(15) = 1.7136 > 0.0606 so, the producer passes.

If the observed results are:

$X_1 = 82$
$X_2 = 15$
$X_3 = 13$

then T = (0.13353) (82) - (0.55962) (15) - (0.22314) (13) = -0.34566 < 0.0606 so, the producer fails.

5.2.3 Fault Seeding Methods

The validity of the demonstration tests for FFD, FFI, FEFI, and FIR is dependent on the ability to insert or simulate faults in the particular system at random. By the term "at random", it is meant that faults are inserted or simulated in such a manner that any one of all possible faults that can occur is equally likely to be inserted or simulated on any given fault insertion or simulation. Of course, to do this, an exhaustive list containing all possible fault types is required. From such a list, the sample faults are chosen at random and inserted or simulated in the system. However, an exhaustive list is usually not available and would be extremely costly to compile. The alternative is to compile an abbreviated list which provides a representative sample of the exhaustive list. A random sample can then be selected from this fault list and simulated or inserted in the system. Such an abbreviated list can be obtained from techniques such as Appendix A to MIL-STD-471A which provides a candidate fault list for maintainability demonstration tests.

It should be pointed out that when more than one FOM requiring fault seeding is being demonstrated, it is not necessary to seed several different sets of faults.

The same set of seeded faults may be used in each demonstration test for which the seeded faults are applicable. Additional fault seeding will only be necessary if some demonstration tests require larger sample sizes due to the test parameters.

6.0 GUIDELINES FOR SPECIFYING BIT/ETE FOMs

This section provides general guidelines for the selection of an appropriate set of BIT/ETE FOMs that should be specified for a given system/equipment. The information presented here is provided as recommendations only for selecting the most suitable BIT/ETE FOMs to specify. The user should use his own discretion when determining which BIT/ETE FOMs will finally be specified based on the specific system/equipment mission and objectives.

This section is broken down into two subsections. The first subsection provides guidance for the selection of BIT/ETE FOMs to specify, given various system/equipment RMA requirements. The second subsection contains guidance for specifying consistent BIT/ETE FOMs.

6.1 GUIDELINES FOR SELECTING BIT/ETE FOMs TO SPECIFY

The selection process for an appropriate set of BIT/ETE FOMs to specify is dependent upon the system/equipment in question and the requirements or goals that are desired. In other words, BIT/ETE FOMs should be specified according to the most important system goals that are desired or required. This section contains a methodology that can be used to identify candidate BIT/ETE FOMs to specify, based on the desired system objectives or requirements.

One important point should be noted: the BIT/ETE FOMs selected will most likely supplement the RMA FOMs that are normally specified (e.g., MTBF, MTTR, and A, or other similar FOMs). With this in mind, it is assumed that <u>at least</u> two of the three RMA FOMs are already included in the system specification. The third FOM, whichever it may be, can be easily determined using the definition of availability

$$\left(A = \frac{MTBF}{MTBF + MTTR}\right).$$

It may turn up, as a result of using the presented guidelines, that the RMA FOMs that are already a part of the system specification may also be prime candidates for BIT/ETE specification. For this reason, the RMA FOMs that also characterize BIT/ETE inherently, remained in the list of BIT/ETE FOMs. Thus, if an RMA FOM is also identified as a prime candidate for BIT/ETE specification, the number of BIT/ETE FOMs required can be kept at a minimum.

6.1.1 Development of BIT/ETE FOM Selection Guidelines Methodology

The matrix shown in Figure 6 along with the system/equipment objectives enumerated in Table 17 are used to select candidate BIT/ETE FOMs. The development of these FOM selection guidelines consisted of the following steps:

1) identify the various system objectives that are related to BIT/ETE
2) correlate the system objectives with the BIT/ETE FOMs that suit them the best
3) rank the BIT/ETE FOMs accordingly, for system objectives that can be characterized by more than one BIT/ETE FOM.

The first step of the BIT/ETE specification guidelines development was straightforward. For each FOM type identified in Section 3, a system objective or reasons for specifying that particular FOM were tabulated. In other words, system objectives or reasons were tabulated depending on when

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REQUIREMENT	FFD	FFA	FFSJ	TFG	TB	FB	TT	FIR(L)	FFI	TFI	MPSL	$MTBF_{BIT}$	$MTTR_{BIT}$	A_{BIT}	MTTR	A	FMAP	FEFI
1) CONTINUOUS PERFORMANCE	2	6		4		3	5									1		
2) ACCURATE STATUS REPORTING	1	4	3	6			5					2						
3) MINIMUM DOWNTIME					7			4	3	6			5		1	2		8
4) LIMITED SPARES								1										
5) MINIMUM SUPPORT COSTS		4	5					1	2									3
6) SPECIFIC SKILL LEVELS SEE NOTE 2	1						7	3	4	8	5				2			6
7) SYSTEM LOCATION								1										2
8) BIT/ETE INTEGRAL TO SYSTEM		3	2									1						
9) ON-LINE TESTING LENGTH/ PERIODICITY					2	1												
10) SOFTWARE TESTING LIMITATIONS																	1	
11) UNDETECTED FAILURES	1			2			3											
12) BIT/ETE OPERABILITY/ ACCURACY		5	4									1	2	3				
13) PHYSICAL AMOUNT OF BIT/ETE	←							SEE NOTE 3										→

NOTES

1. FOR THE AVERAGE RANKING, IF TWO OR MORE FOMs HAD THE SAME AVERAGE RANK, THE FOM THAT HAD THE HIGHER RANK FROM THE BIT/ETE EVALUATION WAS RANKED HIGHER.
2. FOR SYSTEMS THAT REQUIRE A SPECIFIC SKILL LEVEL TO MAINTAIN A SYSTEM, MPSL SHOULD BE SPECIFIED. THE OTHER FOMs LISTED CAN BE USED TO IMPOSE REQUIREMENTS THAT ARE DUE TO THE MPSL REQUIREMENT.
3. FOR SYSTEMS THAT DESIRE THIS OBJECTIVE, THE BIT/ETE FOM THAT CHARACTERIZES THE PHYSICAL LIMITATION SHOULD BE SPECIFIED.

Figure 6. Correlation of RMA and BIT/ETE Objectives with the Defined BIT/ETE FOMs

TABLE 17. SYSTEM/EQUIPMENT RMA AND BIT/ETE OBJECTIVES

1. A high confidence of continuous performance of system/equipment requirements is desired and there are no physical constraints (i.e., redundancy can be implemented).
2. A high confidence of the system's correct status (i.e., operational or down) is needed to determine proceed/abort decisions.
3. Minimum downtime due to failures is critical and physical constraints restrict the use of redundancy.
4. Amount of spares available will be limited.
5. Minimum maintenance and support costs are desired.
6. Specific skill levels will be required to maintain the system/equipment.
7. System/equipment location will restrict the amount of maintenance available (i.e., remote facilities).
8. BIT/ETE failures will be detrimental to system reliability.
9. The periodicity and length of on-line testing is critical to system operations (e.g., in redundant systems where switchover times must occur as soon as possible).
10. The amount of memory for resident software diagnostics (i.e., for continuous monitoring capabilities) is limited.
11. Undetected failures are hazardous to system safety.
12. A high confidence of BIT/ETE operability and accuracy is desired.

and why a BIT/ETE FOM would be specified. For example, if the amount of spares available for a system is limited, then FIR(L) with a high resolution (i.e., average RI group size relatively low) would be a good BIT/ETE FOM to specify.

The system objectives identified were general in order to maintain an overall system applicability. Table 17 summarizes the various system objectives identified that pertain to BIT/ETE.

The next step was to correlate the identified system objectives with the various BIT/ETE FOMs. A majority of work for this step was accomplished during the first step. As a check (to make sure all the system objectives were identified for each BIT/ETE FOM), each FOM was checked against all the system objectives identified to determine if there were any other existing correlations. The results of this step are shown in matrix form in Figure 6. The matrix relates the BIT/ETE FOMs (tabulated across the top row of the matrix) with the identified system objectives (tabulated down the left side of the matrix). For brevity, the system objectives have been denoted by numerals and abbreviated titles, that refer to the numbered system objectives tabulated in Table 17.

The final step in the guidelines development process was to determine which BIT/ETE FOMs were the best candidates to fulfill each system objective. The method used was a ranking of the BIT/ETE FOMs by evaluation scores. Two methods were used for ranking the BIT/ETE FOMs. The first method ranked the FOMs according to the evaluation results of Section 4.2 (FOM suitability evaluation). The second method used was a ranking of the BIT/ETE FOMs according to their suitability towards the system objective it pertains to (i.e., the FOM that fit the objective the best was ranked the highest). The ranking results are tabulated in the associated boxes of Figure 6. Each box contains three pieces of data: 1) the FOM ranking due to evaluation results of Section 4.2, 2) the ranking due to the FOM's suitability towards the system objective, and 3) the ranking of the average of R_1 and R_2 (e.g., the rank obtained from the average of the two ranking methods.) For cases where the average rank was the same for more than one FOM, the FOM with the higher ranking due to the evaluation results of Section 4.2 was ranked higher. The format of the rankings presented in Figure 6 is shown in Figure 7 below:

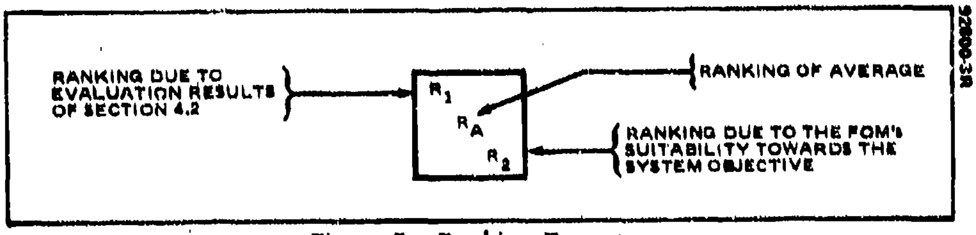

Figure 7. Ranking Format

Three rankings were given so the user would have a choice in selecting the ranking scheme that was more important to him. The rankings are very similar and the use of any ranking should not significantly affect the group of FOMs selected.

6.1.2 <u>Use of the BIT/ETE FOM Specification Guidelines Matrix</u>

Selection of an appropriate set of BIT/ETE FOMs for a system is facilitated by the use of the BIT/ETE FOM specification guidelines matrix of Figure 6.

Use of the guidelines matrix includes the following steps (each of which is expanded upon in the following paragraphs):

1) determine which system objectives are desired for the system in question
2) for the system objectives selected, determine which FOMs are the best candidates by using one of the following techniques:
   a) based on the BIT/ETE FOM evaluation ranking
   b) based on the system objective rankings
   c) based on the average ranking
   d) based on the user's judgment
3) select an adequate number of FOMs

Selection of the System Objectives: This task consists of selecting, out of the list of BIT/ETE objectives, those that pertain to the objectives desired for the system in question. The format of the table is arranged such that the user scans the list of possible objectives in Table 17 and selects the objective(s) most representative of those desired.

The list of system objectives is very generalized and the user should use discretion when applying the presented methodology for selecting BIT/ETE FOMs. Only the necessary system objectives should be selected.

Selection of the BIT/ETE FOMs: The matrix is set up such that when a system objective is selected, the user scans the row for the list of applicable FOMs. Selection of the appropriate FOM can be accomplished several ways. It is recommended that the BIT/ETE FOM with the best average ranking be the specified FOM. However, the matrix leaves room for flexibility by listing all the applicable FOMs and alternative selection processes, such as rankings by system objective suitability, and rankings by the BIT/ETE FOM evaluations of Section 4.

The average ranking (BIT/ETE FOM evaluation ranking and the system objective ranking) is recommended since it accounts for the ability of a FOM to be used by the producer and it accounts for the suitability of the BIT/ETE FOM towards the consumer's requirement objective.

Selection of an Adequate Number of FOMs: In the process of identifying the desired objectives and the most appropriate BIT/ETE FOM associated with the objective, there may be some duplication in the BIT/ETE FOMs selected (i.e., one BIT/ETE FOM may be best suited for more than one BIT/ETE objective). The problem that arises is determining how many BIT/ETE FOMs should be specified. The minimum number of BIT/ETE FOMs that should be specified are the unique FOMs that have been identified by the desired BIT/ETE objectives and the aforementioned selection process. However, if the user so desires, he may select alternative FOMs (e.g., the FOMs that have the next highest ranking or any other FOM related to the BIT/ETE objective) for the cases when there are duplication.

6.2 SPECIFICATION OF CONSISTENT BIT/FTE FOMs

Once an appropriate set of BIT/FTE FOMs has been selected, numerical values must be assigned to them. Specific values for BIT/FTE FOMs are dependent upon the system type, the system environment, the maintenance concept, and especially the objectives and needs of the consumer. Due to a FOM's dependency upon the aforementioned factors, no attempt was made to define specific values for each BIT/FTE FOM. However, typical values for each BIT/FTE FOM, where possible, were determined and are presented in Table 18. The range of values presented were based on the specified values that have been experienced in prior specifications (specifically the specifications surveyed in Section 2) and should be used for guidance only.

Due to the advancement of state of the art electronics the need for better and more sophisticated BIT/FTE has a great impact on the values that should be specified. Thus values specified should reflect the additional capability required.

The remainder of this section addresses the specifications of BIT/FTE FOMs that are numerically (and qualitatively or intuitively) consistent.

TABLE 18. VALUES FOR FOM SPECIFICATIONS

FOM	Typical Values
FFD	0.95 - 0.99
FFA	0.01 - 0.10
FFSI	0.01 - 0.10
T_{FD}	system dependent
T_{FI}	system dependent
T_{II}	system dependent
FT	0.95 - 0.99
FIR(L)	0.90(1); 0.95(2); 1.00(3)
FFI	0.90 - 0.99
T_{FI}	system dependent
MPSL	system dependent
$MTBF_{B/F}$	system dependent
$MTTR_{B/F}$	system dependent
$A_{B/F}$	system dependent
MTTR	system dependent
A	system dependent
FFFI	no data available

6.2.1 Guidelines For Specifying Consistent BIT/ETE FOMs

When specifying BIT/ETE FOMs it is of the utmost importance that the numerical values specified for the BIT/ETE FOMs do not contradict each other. When specifying multiple BIT/ETE FOMs together they must be consistent. FOM consistency is a problem when FOMs that are interrelated are specified together. The purpose of this section is to identify the BIT/ETE FOMs that are interrelated and determine how the specification of one FOM affects how another FOM may be specified.

FOM consistency must exist both quantitatively and qualitatively (or intuitively). First of all, if two or more FOMs are related quantitatively, then the specification of one of the FOMs has an impact on what the numerical value of any related FOMs can be. For example, if the mean time to repair (MTTR) and the mean fault isolation time (T_{FI}) are to be specified together, then in order to be consistent, the value specified for T_{FI} must be less than the value specified for MTTR. This is an obvious case, since T_{FI} is a time element within MTTR. In other cases, the specification of consistent FOMs is not so obvious. For this reason, an interrelationships analysis was performed on the BIT/ETE FOMs. Once this task was completed, it was easier to determine how related FOMs should be specified.

Figure 8 is a matrix identifying which BIT/ETE FOMs are interrelated. The notation used for the matrix is as follows:

- D denotes that a quantitative relationship exists between the two FOMs.
- Q denotes that a qualitative or intuitive relationship exists.
- I denotes that a relationship can be determined indirectly (i.e., by using the relationship of two other FOMs).

Table 19 summarizes the constraints that must be followed when related FOMs are specified together. The table is organized with the two related FOMs denoted on the left side of the table and the constraint imposed on the right side. It should be noted here that the only FOMs that are directly related (i.e., D and Q on the matrix) are referenced here. Thus, constraints for FOMs that are indirectly related can be determined by combinations of the indicated constraints. The number in the leftmost column (relationship number), which denotes the corresponding row and column entry from the matrix of Figure 8, is indicated for reference purposes only.

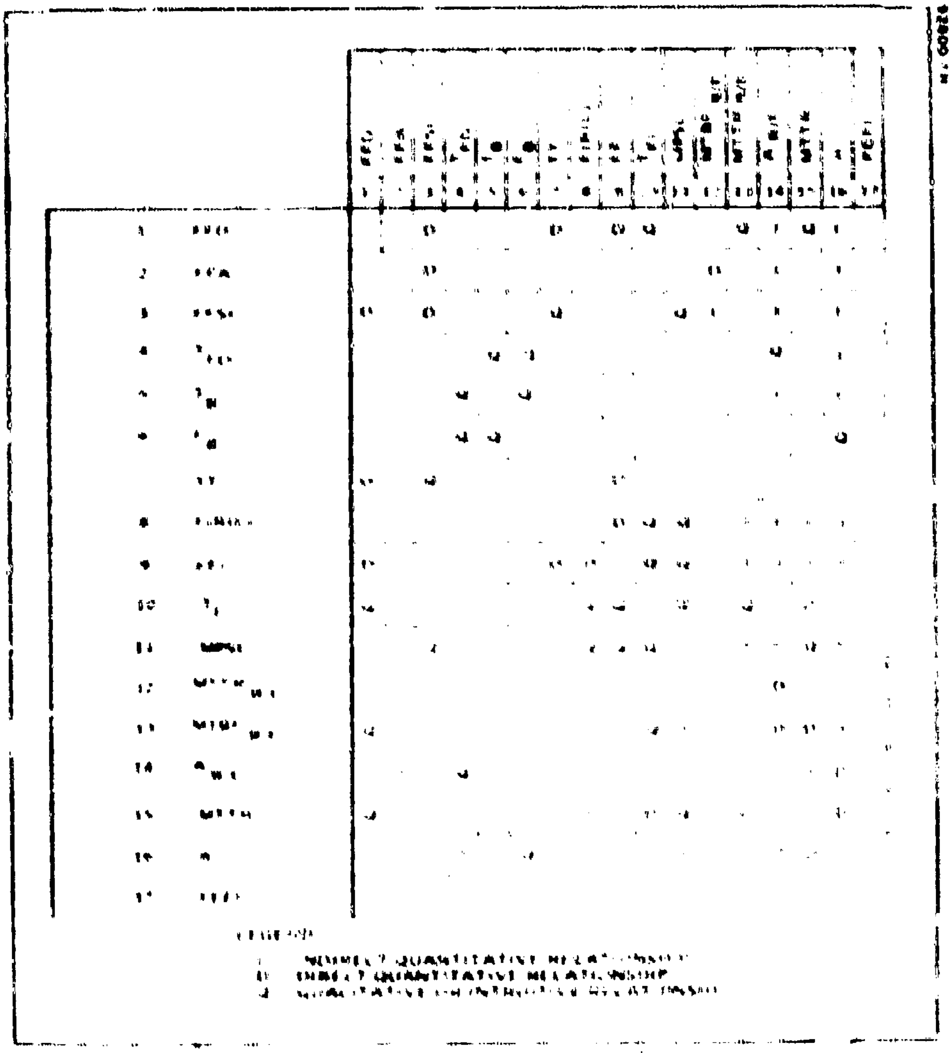

Figure 8. BIT/FTI FOM Interrelationship Matrix

TABLE 19. CONSTRAINTS WHEN SPECIFYING RELATED FOMs

Relationship Number	FOM_1	FOM_2	Constraint
Quantitative Constraints			
1-3	FFD	FFSI	(1 - FFD) [illegible] FFSI
1-7	FFD	TT	FFD [illegible] TT
2-3	FFA	FFSI	FFSI [illegible] FFA
5-6	T_B	F_B	$(F_B)^{-1}$ [illegible] T_B
7-9	TT	FFI	(FFI) x (FFD) [illegible] TT
8-9	FIR(L)	FFI	$FIR(L_{max})$ [illegible] FFI
10-15	T_{FI}	MTTR	T_{FI} [illegible] MTTR (see 10-15 below also)
12-14	$MTBF_{BIT}$	A_{BIT}	by definition $A_{BIT} = \frac{MTBF_{BIT}}{MTBF_{BIT} + MTTR_{BIT}}$
13-14	$MTTR_{BIT}$	A_{BIT}	(same as above)
15-16	MTTR	A	by definition $A = \frac{MTBF}{MTBF + MTTR}$
Qualitative or Intuitive Constraints			
1-10	FFD	T_{FI}	A low T_{FI} is typically the result of extensive BIT/ETE capability. This same capability typically results in a high FFD.
3-7	FFSI	TT	A high TT implies that most components, functions, etc. are tested and correspondingly a low number of undetected failures result. Therefore FFSI is also low.
4-5	T_{FD}	T_B	Fault detection is typically a result of on-line software testing. Therefore if T_{FD} is low then T_B should also be as low.
4-6	T_{FD}	F_B	As noted in 4-5 fault detection is usually accomplished by on-line testing. Therefore if T_{FD} is low then the time between tests $(F_B)^{-1}$ should also be low.

TABLE 19. CONSTRAINTS WHEN SPECIFYING RELATED FOMS (Continued)

Relationship Number	FOM_1	FOM_2	Constraints
8-10	FIR(L)	T_{FI}	A high FIR(L) is typically the result of extensive BIT/ETE capability. The capability typically results in a high degree of BIT/ETE fault isolation, therefore a low T_{FI}.
8-11	FIR(L)	MPSL	A high FIR(L) is typically the result of extensive BIT/ETE capability, thus a high degree of faults are isolated with BIT/ETE. This typically results in a lower MPSL required to maintain the system since fault isolation is a function of the BIT/ETE.
9-10	FFI	T_{FI}	A high FFI is typically the result of extensive BIT/ETE capability. The capability typically results in a high degree of BIT/ETE fault isolation, therefore a low T_{FI}.
9-11	FFI	MPSL	A high FFI is typically the result of extensive BIT/ETE capability, thus a high degree of faults are isolated with BIT/ETE. This typically results in a lower MPSL required to maintain the system since fault isolation is a function of the BIT/ETE.
10-11	T_{FI}	MPSL	Without any implications to the amount of BIT/ETE there is, a low MPSL typically results in a high T_{FI}.
10-15	T_{FI}	MTTR	Since T_{FI} is an element of MTTR it should be smaller. Typically MTTR consists of several other elemental times (e.g., disassembly, reassembly, checkout, etc.). Therefore, T_{FI} should be considerably less than MTTR.
11-15	MPSL	MTTR	Without any implications to the amount of BIT/ETE there is, a low MPSL typically results in a high MTTR.

Not only should the selected BIT/ETE FOM's be quantitatively consistent, they should also be qualitatively or intuitively consistent. For example, it was stated previously that the specified MTTR must be greater than the specified T_{FI}, when specified together. It is intuitive to say that T_{FI} should be considerably less than MTTR (or vice versa). This is obvious since MTTR is usually comprised of fault isolation time, disassembly time, interchange time, reassembly time, and checkout time. No specific constraints can be determined for FOMs that are qualitatively related. However, general guidelines can be set up to avoid these types of inconsistencies. Table 19 also summarizes the constraints on FOM specifications for qualitatively related FOMs.

7.0 INTEGRATION OF BIT/FTF FOMs WITH CURRENT MAINTAINABILITY PROGRAMS

This section discusses how the proposed BIT/FTF FOMs and their appropriate demonstration and analysis techniques can be integrated into future maintainability program plans. A review of the standard maintainability program of MIL-STD-470 identifies the major tasks as

a. Prepare maintainability program plan.

b. Perform maintainability analysis.

c. Prepare inputs to the detailed maintenance concept and detailed maintenance plan.

d. Establish maintainability design criteria.

e. Perform design trade-offs.

f. Predict maintainability parameter values.

g. Incorporate and enforce maintainability requirements in subcontractor and vendor contract specifications.

h. Integrate other items.

i. Participate in design reviews.

j. Establish data collection, analysis and corrective action system.

k. Demonstrate achievement of maintainability requirements.

l. Prepare maintainability status reports.

Table 20 summarizes how each major task is applicable to BIT/FTF FOM specifications. The following subparagraphs discuss in detail how each major task can be implemented for BIT/FTF FOMs.

- Prepare maintainability program plan – the maintainability program plan is a description of how the contractor intends to conduct the maintainability portion of a system program, to meet the specified requirements. This consists of identifying the work to be accomplished for each task, the time phasing of each task, organizational and administrative responsibilities, allocation and prediction techniques that are to be used, etc.... All the aforementioned tasks can easily be applied to BIT/FTF FOM specifications.
- Perform maintainability analysis – This task requires an analysis of maintainability requirements. This consists of translating and allocating the maintainability requirements down to all functional levels where applicable. For BIT/FTF FOM specifications some method must be developed to

TABLE 20. INTEGRATION OF BIT/ETE PROGRAM TASKS WITH A MAINTAINABILITY PROGRAM

MIL-STD-470 Maintainability Program Tasks	Applicability to BIT/ETE Program Tasks
1. Prepare Maintainability Program Plan	Direct Applicability
2. Perform Maintainability Analysis	Requires a method of allocating requirements to lower levels (e.g., similar to maintainability allocations)
3. Prepare Inputs to the Detailed Maintenance Concept and Detailed Maintenance Plan	Direct Applicability
4. Establish Maintainability Design Criteria	Requires guidelines for designing BIT/ETE (e.g., see NAVMAT 3960)
5. Perform Design Tradeoffs	Direct Applicability
6. Predict Maintainability Parameter Values	Requires a prediction or analysis technique (refer to Section 5.1)
7. Incorporate and Enforce Maintainability Requirements in Subcontract and Vendor Specifications	Requires a method of allocating requirements to lower levels (see task 2 above)
8. Integrate Other Items	Requires a method to combine lower level parameters or requirements (see task 6 or 2 above)
9. Participate in Design Reviews	Direct Applicability
10. Establish Data Collection, Analysis, and Corrective Action System	Direct Applicability
11. Demonstrate Achievement of Maintainability Requirements	Requires a demonstration technique (see Section 5.2)
12. Prepare Maintainability Status Reports	Direct Applicability

allocate the BIT/ETE requirements down to the functional levels. The allocation methodology should be similar to existing maintainability allocation techniques and should address factors such as RI failure rates, complexity (difficulty) of BIT/ETE implementation, associated maintainability considerations, and cost factors where available. This requires an analysis of each functional level's BIT/ETE capabilities (i.e., what degree of BIT/ETE can be implemented for each functional level) in addition to currently performed reliability and maintainability analyses.

- Prepare inputs to the detailed maintenance concept and detailed maintenance plan – The objective of this task is to provide support to the development of the detailed maintenance concept and maintenance plan. This includes an analysis of the available maintenance resources (e.g., personnel, documentation, facilities, etc.) and the resources that are required to achieve the specified maintainability characteristics. This task is directly applicable for BIT/FTF specifications.

- Establish maintainability design criteria – The objective of this task is to establish and maintain maintainability design criteria. Establishing the design criteria consists of defining the maintainability features to be included in the design, in order to meet the specified maintainability requirements. Some examples of design guidelines are: accessibility, test points, interchangeability, fail safe features, etc.... This task is directly applicable to BIT/FTF FOM specification since maintainability design guidelines can also be established for BIT/FTF FOMs. RADC-TR-78-224, A Design Guide for Built-In-Test, is a good source of BIT/FTF design features and approaches.

- Perform design tradeoffs – This task requires the reanalysis and documentation of any changes that are the result of design tradeoffs. This also pertains to BIT/FTF analysis.

- Predict maintainability parameters – This task requires the prediction of the quantitative maintainability parameters for the planned design configuration. For BIT/FTF parameters (FOMs), the quantitative values can be predicted using the techniques discussed in Section 5.1 of this report. Additional prediction methodologies need to be developed for some FOMs (e.g., CFA, and FFSD).

- Incorporate and enforce maintainability requirements in subcontractor and vendor specifications – This task consists of specifying quantitative maintainability requirements, on vendor and subcontractor procured items. This can also be accomplished for BIT/FTF requirements by using the allocations techniques discussed previously.

- Integrate other items – This task consists of determining the overall quantitative maintainability parameters which includes government furnished equipment or associate contractor supplied equipment. This is also applicable to quantitative BIT/FTF parameters provided that a method exists to combine lower indenture level BIT/ETE parameters into higher levels. This can be accomplished by the reverse process of the allocations technique or by using the analysis methods that are presented in Section 5.1.

- Participate in design reviews – This task consists of reviewing the analysis data to assure accomplishment of the specified requirements in appropriate stages of system/equipment development. This task is directly applicable to the periodic review of BIT/ETE characteristics.
- Establish data collection, analysis, and corrective action system – This task consists of establishing a data collection system such that the data obtained can be used to provide further evidence that the specified requirements have or have not been met. A data collection system established for the purpose of collecting maintainability data can be directly expanded to include the collection and review of BIT/ETE data.
- Demonstrate achievement of maintainability requirements – This task consists of statistically demonstrating the achieved values of the maintainability parameters using the demonstration techniques provided in MIL-STD-471. The demonstration of the quantitative BIT/ETE parameters can be accomplished using the techniques discussed in Section 5.2 of this report. For many of the BIT/ETE FOMs, the specified maintainability tests can be expanded or the data used directly to evaluate BIT/ETE requirements.
- Prepare maintainability status reports – At intervals determined or approved by the procuring activity, status reports shall be submitted which provide the current assessments of the maintainability parameters and any other information pertaining to the maintenance of the system. This can be directly applied to BIT/ETE parameters and BIT/ETE related information.

8.0 CONCLUSIONS/RECOMMENDATIONS

The program objectives identified in Section 1 of this document have been accomplished. The results obtained thru this study provide the necessary information to adequately specify, analyze, and demonstrate the BIT/ETE capabilities contained in a system/equipment. The methodologies developed are compatible with existing maintainability program techniques and allow BIT/ETE requirements to be easily integrated into standard maintainability programs.

Specific results of this study include:

1) The data collection task showed that the BIT/ETE FOMs currently specified/used do not cover all aspects of BIT/ETE capability and are ambiguous and inconsistent. This study establishes firm definitions of the BIT/ETE FOMs examined. It is recommended that the established definition or variation thereof be incorporated into a military standard, such as MIL-STD-721.

2) Methodologies have been defined to adequately analyze and demonstrate system/equipment BIT/ETE capabilities. Analysis methods consist of rate dependent techniques, time dependent techniques, combined rate and time dependent techniques, and current maintainability analysis techniques. Demonstration methods consist of statistical demonstrations using a binomial distribution, a multinomial distribution, and current maintainability demonstration techniques.

3) A technique was developed to methodically select the BIT/ETE FOMs that should appear in a system/equipment specification based on the desired system/equipment objectives. Along with the developed technique, guidelines have been presented to aid the user in specifying numerical values for the BIT/ETE FOMs and constraints that must be followed when specifying related BIT/ETE FOMs.

4) This study provides the necessary tools required to integrate the defined BIT/ETE FOMs into standard maintainability programs.

The results of this study provide the foundation for the consistent specification and verification of effective BIT/ETE FOMs. Enhancement of the provided capabilities is recommended by further studies in the following areas.

1) False Alarms – Investigate and analyze the causes of false alarms, specifically drift and noise related effects. Develop methodologies for the analysis of false alarms including frequency of occurrence and factors affecting their occurrence. Develop techniques for physically demonstrating false alarms including inducement, simulation and/or modeling.

2) Automated Circuit Analysis – Investigate the current methodologies available for automated (computerized) circuit analysis. Compile the available techniques and develop new techniques as necessary to perform automated analysis of circuits relative to out-of-tolerance conditions, transient conditions, failure modes and effects, and undetected failures. These analyses could be directly applied to the evaluation of BIT/FTF FOMs such as FFD, FFA, and FFSI.

3) Cost Tradeoffs – The evaluation of BIT/FTF FOMs presented in Section 4 and the guideline for the selection of specification of these FOMs presented in Section 6 have purposely avoided cost relationships. The subject of cost is a significant factor in the selection and implementation of BIT/FTF, but the analysis of cost is as involved as the entire study of BIT/FTF. First, cost must be defined (e.g., design cost, recurring production costs, nonrecurrent costs, life cycle cost, documentation cost, associated maintenance manpower costs, etc.). After cost is defined (and the definitions are as varied as the system for which the definitions are made), it must then be related to BIT/FTF characteristics. For example, fault isolation resolution to a single RI 90 percent of the time for one million dollars in design cost, is equivalent to isolation to a single RI 80 percent of the time for half a million dollars. Such an equivalent must consider all related factors such as mission criticality, spares availability, personnel skill levels, support equipment, etc.. The development of typical BIT/FTF FOM and cost relationships and quantitative interrelationships between BIT/FTF FOMs would provide a very useful tradeoff technique for the selection and specification of FOMs.

BIBLIOGRAPHY

1. Angus, J. E., Schafer, R. E., "Statistical Demonstration of Fault Isolation Requirements", submitted to IEEE Transactions on Reliability, April 1979.

2. Griswold, G. H., Retterer, B. C., Balaban, H. S., Mitsopoulas, A. C., Maintainability Prediction and Demonstration Techniques, June 1970 (RADC-TR-70-89) AD 872873.

3. Hoel, Paul G., Introduction to Mathematical Statistics, 4th Ed., John Wiley & Sons, New York 1971.

4. MIL-E-5400R, Electronic Equipment, Airborne, General Specification For, 31 October 1975.

5. MIL-E-16400G (Navy), Electronic, Interim Communication and Navigation Equipment, Naval Ship and Shore: General Specification For, 24 February 1966.

6. MIL-HDBK-472, Maintainability Prediction, 24 May 1966

7. MIL-STD-1309B, Definition of Terms For Test, Measurement and Diagnostic Equipment, 30 May 1975.

8. MIL-STD-1390B, Level of Repair, 1 December 1976.

9. MIL-STD-1591, On-Aircraft, Fault Diagnosis, Sub-System, Analysis/Synthesis of, 3 January 1977.

10. MIL-STD-415D, Test Provisions for Electronic Systems and Associated Equipment, Design Criteria For, 1 October 1969

11. MIL-STD-454D, Standard General Requirements For Electronic Equipment, 15 March 1978.

12. MIL-STD-470, Maintainability Program Requirements (For Systems and Equipments), 21 March 1966.

13. MIL-STD-471A, Maintainability Verification/Demonstration/Evaluation, 27 March 1973.

14. MIL-STD-721B, Definition of Effectiveness Terms for Reliability, Maintainability, Human Factors, Safety, 10 March 1970.

15. MIL-STD-781B, Reliability Tests: Exponential Distribution, 15 November 1967.

16. Naval Air Systems Command, Maintainability of Avionics Equipment and Systems, General Requirements For, 1 January 1969, (AR-10A).

17. NAVMAT-3960, Built-In Test (BIT) Design Guide, 1 July 1976.

18. Pliska, T. F., Jew, F. L., Angus, J. F., Maintainability Prediction and Analysis Study, Hughes Aircraft Company, Fullerton, California, July 1978 (RADC-TR-78-169), (AD A059 753.

19. Postlewaite, C. W., et. al., A Guide to the Application of Built in Test to Navy Avionic Equipment, Arinc Research Corp., February 1968 (AD 837694).

APPENDIX A

A.1 BINOMIAL DISTRIBUTION TABLES FOR STATISTICAL DEMONSTRATION OF FFD, FFI AND FEFI

The following tables provide the probabilities of passing the demonstration tests described in Section 5.2.1. The tables presented are for a presentative sample of test statistics. That is, the tables presented are for samples sizes of n = 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90 and 100, and pass/fail criterion (for each n) of k = 0.80n, 0.80n+1, 0.80n+2, ..., n-1. Usage of these tables are described in Section 5.2.1 of this report and in Section A.2 of this appendix.

The values presented in the tables were computed using the following:

$$\gamma(p) = \sum_{i=k+1}^{n} \binom{n}{i} p^{i}(1-p)^{n-i}$$

where:

n = sample size,

k = pass/fail criterion,

p = the true value of the FOM being demonstrated (of the type discussed in Section 5.2.1.1).

$\gamma(p)$ = the probability of passing the demonstration test if p is the true value of the FOM being demonstrated (of the type discussed in Section 5.2.1.1).

The producer risk α is given by $\alpha = 1 - \gamma(p_0)$ where p_0 is the design goal, and the consumer risk β is given by $\beta = \gamma(p_1)$ where p_1 is the minimum acceptable.

A.2 Step-by Step Procedure for Designing a Demonstration Test Using the Tables

Case 1: n, p_1, β known, k and p_0 must be determined (assuming a reasonable value for α, say $\alpha = \beta$).

Step 1 Example the tables in Appendix A for those cases where sample size is n.

Step 2 Find the value of k (i.e., pass/fail criterion) for which the table entry (i.e., "probability of passing the test") corresponding to p_1 (i.e., p_1 as the true value of p) is closest to the desired β. This is the value of k required and the table entry corresponding to p_1 is the exact value of β.

Step 3 For the n given and k determined in Step 2, search the table corresponding to sample size n and pass/fail criterion k for the entry (i.e., "probability of passing the test") equal (interpolation may be necessary) to $1 - \alpha$. The corresponding true value of p is the required p_0 (for the assumed α).

Case 2: β, p_1, α, p_0 all known, n and k must be determined.

Step 1 Compute a first approximation to n using equation 5.2.1.1.6.

Step 2 Compute a first approximation to k using equation 5.2.1.1.7.

Step 3 Enter the table in Appendix A corresponding to a sample size of n and pass/fail criterion of k. Read the exact value of β from the table entry (i.e., "probability of passing test") corresponding to p_1 (i.e., p_1 as the true value of p). Compute the exact value of α as one minus the table entry corresponding to p_0 (i.e., p_0 as the true value of p).

Step 4 Compare the exact values of α, β with the original values of α, β. If they are close enough (here, "close enough" is determined by user preference), the test is determined by using the values of n and k determined in Steps 1 and 2. If the exact values of α, β are not close enough to the original values of α, β, then vary k and/or n (usually increase n) slightly and repeat Step 3. Continue until the exact values of α, β are close enough to the original values of α, β.

SAMPLE SIZE= 20	PASS/FAIL CRITERION 16	SAMPLE SIZE= 20	PASS/FAIL CRITERION 17	SAMPLE SIZE= 20	PASS/FAIL CRITERION 18
TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.22516	0.750	0.09124		
0.755	0.24069	0.755	0.09969		
0.760	0.25695	0.760	0.10466		
0.765	0.27367	0.765	0.11615		
0.770	0.29151	0.770	0.12844		
0.775	0.30904	0.775	[illegible]	0.775	0.04150
0.780	0.32867	0.780	0.15225	0.780	0.04615
0.785	0.34641	0.785	0.16148	0.785	0.05135
0.790	0.36496	0.790	0.17699	0.790	0.05663
0.795	0.38991	0.795	0.19111	0.795	0.06242
0.800	0.41104	0.800	0.20604	0.800	0.06918
0.805	0.43361	0.805	0.22197	0.805	0.07653
0.810	0.45412	0.810	0.23869	0.810	0.08412
0.815	0.47516	0.815	0.25637	0.815	0.09261
0.820	0.49248	0.820	0.27479	0.820	0.10181
0.825	0.52637	0.825	0.29421	0.825	0.11184
0.830	0.55041	0.830	[illegible]	0.830	0.12264
0.835	0.57004	0.835	0.33605	0.835	0.13444
0.840	0.59900	0.840	0.35900	0.840	0.14713
0.845	0.62533	0.845	0.38162	0.845	0.16081
0.850	0.64773	0.850	0.40699	0.850	0.17556
0.855	0.67192	0.855	[illegible]	0.855	0.19161
0.860	0.69900	0.860	0.45652	0.860	0.20645
0.865	0.71950	0.865	0.48117	0.865	0.22446
0.870	0.74248	0.870	0.50794	0.870	0.24415
0.875	0.76533	0.875	0.53521	0.875	0.26495
0.880	0.78736	0.880	0.56311	0.880	0.28913
0.885	0.80841	0.885	0.59112	0.885	0.31263
0.890	0.82955	0.890	0.61977	0.890	0.33757
0.895	0.84954	0.895	0.64836	0.895	0.36396
0.900	0.86709	0.900	0.67691	0.900	0.39175
0.905	0.88444	0.905	0.70536	0.905	0.42097
0.910	0.90667	0.910	0.73345	0.910	0.45160
0.915	0.91567	0.915	0.76093	0.915	0.48358
0.920	0.92738	0.920	[illegible]	0.920	0.51686
0.925	0.94175	0.925	0.81490	0.925	0.55132
0.930	0.95282	0.930	0.83939	0.930	0.58686
0.935	0.96261	0.935	0.86274	0.935	0.62336
0.940	0.97103	0.940	0.88571	0.940	0.66065
0.945	0.97828	0.945	0.90648	0.945	0.69857
0.950	0.98628	0.950	0.92452	0.950	0.73596
0.955	0.98887	0.955	0.94134	0.955	0.77341
0.960	0.99250	0.960	0.95616	0.960	0.81034
0.965	0.99536	0.965	0.96869	0.965	0.84612
0.970	0.99735	0.970	0.97899	0.970	0.88016
0.975	0.99863	0.975	0.98736	0.975	0.91176
0.980	0.99943	0.980	0.99291	0.980	0.94128
0.985	0.99987	0.985	0.99682	0.985	0.96625
0.990	0.99996	0.990	0.99898	0.990	0.98514
0.995	0.99999	0.995	0.99987	0.995	0.99633
1.000	1.00000	1.000	1.00000	1.000	1.00000

SAMPLE SIZE= 20 TRUE VALUE OF P	PASS/FAIL CRITERION= 19 PROBABILITY OF PASSING TEST
0.855	0.04354
0.860	0.04497
0.865	0.05[illegible]
0.870	0.06171
0.875	0.0[illegible]
0.880	0.07756
0.885	0.08[illegible]
0.890	0.09723
0.895	0.10[illegible]
0.900	0.12[illegible]
0.905	0.13[illegible]
0.910	0.15[illegible]
0.915	0.16521
0.920	0.18[illegible]
0.925	0.21[illegible]
0.930	0.23[illegible]
0.935	0.2[illegible]
0.940	0.29311
0.945	0.32[illegible]
0.950	0.35[illegible]
0.955	0.39[illegible]
0.960	0.44[illegible]
0.965	0.49[illegible]
0.970	0.54[illegible]
0.975	0.60[illegible]
0.980	0.65[illegible]
0.985	0.71[illegible]
0.990	0.81[illegible]
0.995	0.95[illegible]
1.000	1.00000

SAMPLE SIZE= 25 TRUE VALUE OF P	PASS/FAIL CRITERION= 20 PROBABILITY OF PASSING TEST
0.750	0.21374
0.755	0.23563
0.760	0.24841
0.765	0.26735
0.770	0.28658
0.775	0.30676
0.780	0.31617
0.785	0.33[illegible]
0.790	0.35[illegible]
0.795	0.37649
0.800	0.42547
0.805	0.44547
0.810	0.4[illegible]
0.815	0.49462
0.820	0.51[illegible]
0.825	0.54927
0.830	0.57[illegible]
0.835	0.60[illegible]
0.840	0.62933
0.845	0.65[illegible]
0.850	0.68[illegible]
0.855	0.70794
0.860	0.73[illegible]
0.865	0.75[illegible]
0.870	0.78[illegible]
0.875	0.81[illegible]
0.880	0.83654
0.885	0.86[illegible]
0.890	0.8[illegible]
0.895	0.89516
0.900	0.91291
0.905	0.9[illegible]
0.910	0.93139
0.915	0.94[illegible]
0.920	0.95[illegible]
0.925	0.96465
0.930	0.97155
0.935	0.97[illegible]
0.940	0.98[illegible]
0.945	0.98[illegible]
0.950	0.99[illegible]
0.955	0.99549
0.960	0.99[illegible]
0.965	0.99865
0.970	0.99922
0.975	0.9996[illegible]
0.980	0.99[illegible]
0.985	0.99997
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 25 TRUE VALUE OF P	PASS/FAIL CRITERION= 21 PROBABILITY OF PASSING TEST
0.750	0.09621
0.755	0.10[illegible]
0.760	0.11[illegible]
0.765	0.12735
0.770	0.14[illegible]
0.775	0.15[illegible]
0.780	0.16[illegible]
0.785	0.18[illegible]
0.790	0.19[illegible]
0.795	0.21525
0.800	0.22[illegible]
0.805	0.25319
0.810	0.27[illegible]
0.815	0.29[illegible]
0.820	0.31[illegible]
0.825	0.34[illegible]
0.830	0.36[illegible]
0.835	0.39[illegible]
0.840	0.42[illegible]
0.845	0.44[illegible]
0.850	0.47[illegible]
0.855	0.49[illegible]
0.860	0.52[illegible]
0.865	0.5[illegible]
0.870	0.58776
0.875	0.61[illegible]
0.880	0.64[illegible]
0.885	0.67[illegible]
0.890	0.7[illegible]
0.895	0.73[illegible]
0.900	0.76[illegible]
0.905	0.79[illegible]
0.910	0.81[illegible]
0.915	0.84[illegible]
0.920	0.86[illegible]
0.925	0.88[illegible]
0.930	0.90[illegible]
0.935	0.92[illegible]
0.940	0.94[illegible]
0.945	0.95[illegible]
0.950	0.96[illegible]
0.955	0.97[illegible]
0.960	0.98[illegible]
0.965	0.98[illegible]
0.970	0.99331
0.975	0.99[illegible]
0.980	0.99[illegible]
0.985	0.99[illegible]
0.990	0.99[illegible]
0.995	0.99999
1.000	1.00000

SAMPLE SIZE= 25 PASS/FAIL CRITERION= 22

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.760	0.04067
0.765	0.0456[illegible]
0.770	0.05120
0.775	0.05737
0.780	0.06401
0.785	0.07144
0.790	0.07957
0.795	0.08849
0.800	0.09823
0.805	0.10884
0.810	0.12035
0.815	0.1333[illegible]
0.820	0.14649
0.825	0.16145
0.830	0.17735
0.835	0.19454
0.840	0.21276
0.845	0.23244
0.850	0.25374
0.855	0.27625
0.860	0.29[illegible]
0.865	0.3[illegible]
0.870	0.35271
0.875	0.37[illegible]
0.880	0.40[illegible]
0.885	0.4[illegible]
0.890	0.4[illegible]
0.895	0.5[illegible]
0.900	0.53[illegible]
0.905	0.57[illegible]
0.910	0.6[illegible]
0.915	0.6[illegible]
0.920	0.67[illegible]
0.925	0.71195
0.930	0.74[illegible]
0.935	0.78[illegible]
0.940	0.81[illegible]
0.945	0.84[illegible]
0.950	0.87[illegible]
0.955	0.89[illegible]
0.960	0.92[illegible]
0.965	0.94[illegible]
0.970	0.96[illegible]
0.975	0.97617
0.980	0.9[illegible]
0.985	0.99536
0.990	0.99[illegible]
0.995	0.99[illegible]
1.000	[illegible]

SAMPLE SIZE= 25 PASS/FAIL CRITERION= 23

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.815	0.04012
0.820	0.04544
0.825	0.05139
0.830	0.05[illegible]
0.835	0.06[illegible]
0.840	0.07371
0.845	0.08[illegible]
0.850	0.09[illegible]
0.855	0.10[illegible]
0.860	0.11480
0.865	0.13[illegible]
0.870	0.14[illegible]
0.875	0.16[illegible]
0.880	0.18[illegible]
0.885	0.20[illegible]
0.890	0.22[illegible]
0.895	0.24[illegible]
0.900	0.27121
0.905	0.29[illegible]
0.910	0.32[illegible]
0.915	0.3[illegible]
0.920	0.39[illegible]
0.925	0.4[illegible]
0.930	0.4[illegible]
0.935	0.51517
0.940	0.55[illegible]
0.945	0.5[illegible]
0.950	0.6[illegible]
0.955	0.6[illegible]
0.960	0.7[illegible]
0.965	0.7[illegible]
0.970	0.8[illegible]
0.975	0.87[illegible]
0.980	0.91[illegible]
0.985	0.9[illegible]
0.990	0.97[illegible]
0.995	0.99[illegible]
1.000	1.00000

SAMPLE SIZE= 25 PASS/FAIL CRITERION= 24

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.880	0.04[illegible]
0.885	0.04[illegible]
0.890	0.05[illegible]
0.895	0.06[illegible]
0.900	0.07179
0.905	0.08[illegible]
0.910	0.09[illegible]
0.915	0.10[illegible]
0.920	0.12[illegible]
0.925	0.14[illegible]
0.930	0.16[illegible]
0.935	0.18[illegible]
0.940	0.21[illegible]
0.945	0.24[illegible]
0.950	0.27739
0.955	0.31[illegible]
0.960	0.36[illegible]
0.965	0.41938
0.970	0.46[illegible]
0.975	0.53[illegible]
0.980	0.60[illegible]
0.985	0.68[illegible]
0.990	0.77[illegible]
0.995	0.88[illegible]
1.000	1.00000

SAMPLE SIZE= 30 TRUE VALUE OF P	PASS/FAIL CRITERION= 24 PROBABILITY OF PASSING TEST	SAMPLE SIZE= 30 TRUE VALUE OF P	PASS/FAIL CRITERION= 25 PROBABILITY OF PASSING TEST	SAMPLE SIZE= 30 TRUE VALUE OF P	PASS/FAIL CRITERION= 26 PROBABILITY OF PASSING TEST
0.750	0.20464	0.750	0.09767	0.755	0.04897
0.755	0.22054	0.755	0.10880	0.760	0.04828
0.760	0.25961	0.760	0.12018	0.765	0.05648
0.765	0.25469	0.765	0.13359	0.770	0.06176
0.770	0.28081	0.770	0.14756	0.775	0.06543
0.775	0.30796	0.775	0.16258	0.780	0.07829
0.780	0.32600	0.780	0.17875	0.785	0.08788
0.785	0.35013	0.785	0.19567	0.790	0.09644
0.790	0.37824	0.790	0.21459	0.795	0.11003
0.795	0.40090	0.795	0.23410	0.800	0.12771
0.800	0.42751	0.800	0.25521	0.805	0.13695
0.805	0.46475	0.805	0.27737	0.810	0.15142
0.810	0.48256	0.810	0.30071	0.815	0.16796
0.815	0.51984	0.815	0.32527	0.820	0.18546
0.820	0.53946	0.820	0.35086	0.825	0.20449
0.825	0.56310	0.825	0.37759	0.830	0.22517
0.830	0.59721	0.830	0.40531	0.835	0.24709
0.835	0.62646	0.835	[illegible]	0.840	0.27048
0.840	0.65445	0.840	0.46349	0.845	0.29554
0.845	[illegible]	0.845	0.49369	0.850	0.32146
0.850	0.71054	0.850	0.52447	0.855	0.34961
0.855	0.73757	0.855	0.55547	0.860	0.37856
0.860	0.76371	0.860	0.58715	0.865	0.40894
0.865	0.78896	0.865	0.61867	0.870	0.44024
0.870	0.81206	0.870	0.65018	0.875	0.47339
0.875	0.83554	0.875	0.68176	0.880	0.50788
0.880	0.85692	0.880	0.71178	0.885	0.54195
0.885	0.87678	0.885	0.74161	0.890	0.57659
0.890	0.89649	0.890	0.77046	0.895	0.61138
0.895	0.91177	0.895	0.79964	0.900	0.64744
0.900	0.92621	0.900	0.82451	0.905	0.68278
0.905	0.94019	0.905	0.84927	0.910	0.71567
0.910	0.95136	0.910	0.87731	0.915	0.75141
0.915	0.96279	0.915	0.89567	0.920	0.78421
0.920	0.97571	0.920	0.91265	0.925	0.81552
0.925	0.97796	0.925	0.92976	0.930	0.84542
0.930	0.98377	0.930	0.94476	0.935	0.87248
0.935	0.98866	0.935	0.95761	0.940	0.89738
0.940	0.99295	0.940	0.96844	0.945	0.91972
0.945	0.99476	0.945	0.97733	0.950	0.93921
0.950	0.99672	0.950	0.98434	0.955	0.95580
0.955	0.99804	0.955	0.98975	0.960	0.96941
0.960	0.99896	0.960	0.99364	0.965	0.98011
0.965	0.99947	0.965	0.99626	0.970	0.9881
0.970	0.99977	0.970	0.99816	0.975	0.99363
0.975	0.99991	0.975	0.99917	0.980	0.99721
0.980	0.99997	0.980	0.99972	0.985	0.99898
0.985	0.99999	0.985	0.99992	0.990	0.99978
0.990	1.00000	0.990	0.99999	0.995	0.99994
0.995	1.00000	0.995	1.00000	1.000	1.00000
1.000	1.00000	1.000	1.00000		

SAMPLE SIZE= 30 PASS/FAIL CRITERION= 27

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.800	0.04418
0.805	0.05043
0.810	0.05745
0.815	0.06532
0.820	0.07412
0.825	0.08394
0.830	0.09490
0.835	0.10407
0.840	0.12036
0.845	0.13614
0.850	0.15140
0.855	0.16925
0.860	0.18871
0.865	0.20903
0.870	0.23296
0.875	0.25787
0.880	0.28470
0.885	0.31347
0.890	0.34420
0.895	0.37604
0.900	0.41135
0.905	0.44763
0.910	0.48553
0.915	0.52467
920	0.56548
0.925	0.60641
0.930	0.64875
0.935	0.69077
0.940	0.73248
0.945	0.77347
0.950	0.81214
0.955	0.84904
0.960	0.88118
0.965	0.91369
0.970	0.93993
0.975	0.96141
0.980	0.97828
0.985	0.98987
0.990	0.99648
0.995	0.99956
1.000	1.00007

SAMPLE SIZE= 30 PASS/FAIL CRITERION= 28

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.845	0.04157
0.850	0.04401
0.855	0.05519
0.860	0.06177
0.865	0.07154
0.870	0.08064
0.875	0.09424
0.880	0.10997
0.885	0.12541
0.890	0.14273
0.895	0.16210
0.900	0.18370
0.905	0.20764
0.910	0.23427
0.915	0.26353
0.920	0.29579
0.925	0.33102
0.930	0.36934
0.935	0.41065
0.940	0.45547
0.945	0.50311
0.950	0.55354
0.955	0.60641
0.960	0.66118
0.965	0.71790
0.970	0.77309
0.975	0.82760
0.980	0.87743
0.985	0.92577
0.990	0.96355
0.995	0.99089
1.000	1.00000

SAMPLE SIZE= 30 PASS/FAIL CRITERION= 29

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.900	0.04239
0.905	0.05006
0.910	0.05905
0.915	0.06960
0.920	0.08197
0.925	0.09644
0.930	0.11337
0.935	0.13315
0.940	0.15626
0.945	0.18321
0.950	0.21464
0.955	0.25125
0.960	0.29386
0.965	0.34342
0.970	0.40101
0.975	0.46785
0.980	0.54548
0.985	0.63546
0.990	0.73970
0.995	0.85833
1.000	1.00000

SAMPLE SIZE= 36	PASS/FAIL CRITERION 28	SAMPLE SIZE= 36	PASS/FAIL CRITERION 29	SAMPLE SIZE= 36	PASS/FAIL CRITERION 30
TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.19190	0.750	0.09762	0.750	0.04101
0.755	0.21025	0.755	0.10960	0.755	0.04702
0.760	0.23091	0.760	0.12244	0.760	0.05378
0.765	0.25221	0.765	0.13641	0.765	0.06135
0.770	0.27672	0.770	0.15179	0.770	0.06981
0.775	0.29842	0.775	0.16864	0.775	0.07925
0.780	0.32327	0.780	0.18651	0.780	0.08971
0.785	0.34921	0.785	0.20432	0.785	0.10129
0.790	0.37618	0.790	0.22440	0.790	0.11497
0.795	0.40469	0.795	0.24546	0.795	0.12811
0.800	0.43286	0.800	0.27209	0.800	0.14349
0.805	0.46232	0.805	0.29606	0.805	0.16020
0.810	0.49240	0.810	0.32290	0.810	0.17854
0.815	0.52292	0.815	0.35036	0.815	0.19831
0.820	0.55375	0.820	0.37892	0.820	0.21964
0.825	0.58469	0.825	0.40964	0.825	0.24254
0.830	0.61563	0.830	0.43926	0.830	0.26718
0.835	0.64424	0.835	0.47070	0.835	0.29320
0.840	0.67644	0.840	0.50501	0.840	0.32068
0.845	0.70606	0.845	0.53536	0.845	0.35059
0.850	0.73406	0.850	0.56566	0.850	0.38075
0.855	0.76243	0.855	0.59260	0.855	0.41274
0.860	0.78924	0.860	0.63521	0.860	0.44599
0.865	0.81451	0.865	0.66251	0.865	0.48022
0.870	0.83811	0.870	0.70026	0.870	0.51545
0.875	0.86090	0.875	0.73143	0.875	0.55126
0.880	0.88170	0.880	0.76201	0.880	0.58751
0.885	0.89948	0.885	0.79104	0.885	0.62389
0.890	0.91456	0.890	0.81961	0.890	0.66018
0.895	0.93144	0.895	0.84445	0.895	0.69581
0.900	0.94402	0.900	0.86616	0.900	0.73072
0.905	0.95626	0.905	0.89084	0.905	0.76467
0.910	0.96399	0.910	0.91191	0.910	0.79682
0.915	0.97415	0.915	0.92757	0.915	0.82731
0.920	0.98040	0.920	0.94289	0.920	0.85570
0.925	0.98611	0.925	0.95681	0.925	0.88172
0.930	0.99030	0.930	0.96782	0.930	0.90516
0.935	0.99345	0.935	0.97681	0.935	0.92556
0.940	0.99576	0.940	0.98317	0.940	0.94372
0.945	0.99738	0.945	0.99047	0.945	0.95876
0.950	0.99844	0.950	0.99275	0.950	0.97097
0.955	0.99918	0.955	0.99543	0.955	0.98058
0.960	0.99959	0.960	0.99756	0.960	0.98775
0.965	0.99982	0.965	0.99876	0.965	0.99290
0.970	0.99995	0.970	0.99944	0.970	0.99620
0.975	0.99996	0.975	0.99979	0.975	0.99834
0.980	0.99999	0.980	0.99996	0.980	0.99937
0.985	1.00000	0.985	1.00000	0.985	0.99983
0.990	1.00000	0.990	1.00000	0.990	0.99997
0.995	1.00000	0.995	1.00000	0.995	1.00000
1.000	1.00000	1.000	1.00000	1.000	1.00000

SAMPLE SIZE= 36 PASS/FAIL CRITERION= 31

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.790	0.04570
0.795	0.05270
0.800	0.06052
0.805	0.06933
0.810	0.07921
0.815	0.09027
0.820	0.10265
0.825	0.11631
0.830	0.13147
0.835	0.14825
0.840	0.16664
0.845	0.18663
0.850	0.20842
0.855	0.23175
0.860	0.25659
0.865	0.28427
0.870	0.31595
0.875	0.34762
0.880	0.38112
0.885	0.41630
0.890	0.45326
0.895	0.49153
0.900	0.53098
0.905	0.57133
0.910	0.61222
0.915	0.65326
0.920	0.69397
0.925	0.73393
0.930	0.77262
0.935	0.80951
0.940	0.84405
0.945	0.87579
0.950	0.90425
0.955	0.92906
0.960	0.94997
0.965	0.96676
0.970	0.97978
0.975	0.98897
0.980	0.99489
0.985	0.99817
0.990	0.99959
0.995	0.99997
1.000	1.00000

SAMPLE SIZE= 36 PASS/FAIL CRITERION= 32

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.825	0.04192
0.830	0.04675
0.835	0.05454
0.840	0.06346
0.845	0.07557
0.850	0.08736
0.855	0.09995
0.860	0.11454
0.865	0.13047
0.870	0.14712
0.875	0.16541
0.880	0.19193
0.885	0.21477
0.890	0.24406
0.895	0.27145
0.900	0.30425
0.905	0.34127
0.910	0.37856
0.915	0.41551
0.920	0.46149
0.925	0.50439
0.930	0.55252
0.935	0.60077
0.940	0.64477
0.945	0.69312
0.950	0.74676
0.955	0.79249
0.960	0.83653
0.965	0.87712
0.970	0.91320
0.975	0.94343
0.980	0.96766
0.985	0.98455
0.990	0.99445
0.995	0.99927
1.000	1.00000

SAMPLE SIZE= 35 PASS/FAIL CRITERION= 33

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.865	0.04034
0.870	0.04701
0.875	0.05483
0.880	0.06581
0.885	0.07712
0.890	0.09017
0.895	0.10517
0.900	0.12238
0.905	0.14203
0.910	0.16461
0.915	0.18979
0.920	0.21866
0.925	0.25066
0.930	0.28644
0.935	0.32646
0.940	0.37047
0.945	0.41936
0.950	0.47203
0.955	0.52871
0.960	0.58901
0.965	0.65217
0.970	0.71722
0.975	0.78272
0.980	0.84527
0.985	0.90325
0.990	0.95214
0.995	0.98617
1.000	1.00000

SAMPLE SIZE= 35	PASS/FAIL CRITERION= 34
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.915	0.04464
0.920	0.05402
0.925	0.06531
0.930	0.07887
0.935	0.09515
0.940	0.11468
0.945	0.13807
0.950	0.16608
0.955	0.19956
0.960	0.23960
0.965	0.28738
0.970	0.34434
0.975	0.41225
0.980	0.49307
0.985	0.58921
0.990	0.70345
0.995	0.83909
1.000	1.00000

SAMPLE SIZE= 40	PASS/FAIL CRITERION= 32
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.18196
0.755	0.20151
0.760	0.22244
0.765	0.24441
0.770	0.26455
0.775	0.29365
0.780	0.31308
0.785	0.34770
0.790	0.37641
0.795	0.40636
0.800	0.43715
0.805	0.46871
0.810	0.50000
0.815	0.53144
0.820	0.56432
0.825	0.59917
0.830	0.63103
0.835	0.66406
0.840	0.69644
0.845	0.72634
0.850	0.75591
0.855	0.78422
0.860	0.81102
0.865	0.83616
0.870	0.85950
0.875	0.88093
0.880	0.90037
0.885	0.91780
0.890	0.93320
0.895	0.94661
0.900	0.95810
0.905	0.96777
0.910	0.97576
0.915	0.98222
0.920	0.98731
0.925	0.99123
0.930	0.99416
0.935	0.99626
0.940	0.99772
0.945	0.99860
0.950	0.99924
0.955	0.99965
0.960	0.99986
0.965	0.99996
0.970	0.99998
0.975	0.99999
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 40	PASS/FAIL CRITERION= 33
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.09422
0.755	0.10806
0.760	0.12273
0.765	0.13745
0.770	0.15466
0.775	0.17206
0.780	0.19023
0.785	0.21333
0.790	0.23596
0.795	0.26027
0.800	0.28604
0.805	0.31318
0.810	0.34173
0.815	0.37170
0.820	0.40290
0.825	0.43520
0.830	0.46843
0.835	0.50242
0.840	0.53676
0.845	0.57177
0.850	0.60666
0.855	0.64136
0.860	0.67556
0.865	0.70899
0.870	0.74139
0.875	0.77244
0.880	0.80203
0.885	0.82979
0.890	0.85556
0.895	0.87915
0.900	0.90045
0.905	0.91947
0.910	0.93603
0.915	0.95035
0.920	0.96236
0.925	0.97223
0.930	0.98015
0.935	0.98631
0.940	0.99094
0.945	0.99429
0.950	0.99661
0.955	0.99812
0.960	0.99905
0.965	0.99957
0.970	0.99981
0.975	0.99994
0.980	0.99998
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 40	PASS/FAIL CRITERION= 36	SAMPLE SIZE= 40	PASS/FAIL CRITERION= 36	SAMPLE SIZE= 40	PASS/FAIL CRITERION= 36
TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.04327	0.780	0.04222	0.815	0.04434
0.755	0.05086	0.785	0.04911	0.820	0.05428
0.760	0.05770	0.790	0.05695	0.825	0.06321
0.765	0.06453	0.795	0.06586	0.830	0.07350
0.770	0.07602	0.800	0.07501	0.835	0.08519
0.775	0.08625	0.805	0.08724	0.840	0.09866
0.780	0.09591	0.810	0.09995	0.845	0.11338
0.785	0.11233	0.815	0.11415	0.850	0.13017
0.790	0.12716	0.820	0.12996	0.855	0.14694
0.795	0.14345	0.825	0.14763	0.860	0.16903
0.800	0.16133	0.830	0.16672	0.865	0.19296
0.805	0.18206	0.835	0.18709	0.870	0.21845
0.810	0.20284	0.840	0.21161	0.875	0.24638
0.815	0.22696	0.845	0.23615	0.880	0.27600
0.820	0.24963	0.850	0.26332	0.885	0.30975
0.825	0.27405	0.855	0.29296	0.890	0.34510
0.830	0.30419	0.860	0.32377	0.895	0.38302
0.835	0.33400	0.865	0.35695	0.900	0.42313
0.840	0.36546	0.870	0.39107	0.905	0.46529
0.845	0.39828	0.875	0.42869	0.910	0.50921
0.850	0.43258	0.880	0.46691	0.915	0.55482
0.855	0.46788	0.885	0.50637	0.920	0.60075
0.860	0.50420	0.890	0.54479	0.925	0.64735
0.865	0.54122	0.895	0.58700	0.930	0.69367
0.870	0.57860	0.900	0.62982	0.935	0.73987
0.875	0.61422	0.905	0.67000	0.940	0.78276
0.880	0.65356	0.910	0.71029	0.945	0.82393
0.885	0.68936	0.915	0.74930	0.950	0.86185
0.890	0.72628	0.920	0.78679	0.955	0.89500
0.895	0.76078	0.925	0.82263	0.960	0.92316
0.900	0.79373	0.930	0.85663	0.965	0.94958
0.905	0.82472	0.935	0.88626	0.970	0.96860
0.910	0.85567	0.940	0.91062	0.975	0.98235
0.915	0.87972	0.945	0.93306	0.980	0.99175
0.920	0.90327	0.950	0.95207	0.985	0.99699
0.925	0.92406	0.955	0.96723	0.990	0.99931
0.930	0.94185	0.960	0.97890	0.995	0.99995
0.935	0.95485	0.965	0.98753	1.000	1.00000
0.940	0.96907	0.970	0.99333		
0.945	0.97877	0.975	0.99690		
0.950	0.98612	0.980	0.99862		
0.955	0.99146	0.985	0.99968		
0.960	0.99512	0.990	0.99995		
0.965	0.99747	0.995	1.00000		
0.970	0.99886	1.000	1.00005		
0.975	0.99955				
0.980	0.99986				
0.985	0.99997				
0.990	1.00000				
0.995	1.00003				
1.000	1.00000				

SAMPLE SIZE= 40	PASS/FAIL CRITERION= 37
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.845	0.04353
0.850	0.04962
0.855	0.05749
0.860	0.06757
0.865	0.07917
0.870	0.09253
0.875	0.10801
0.880	0.12603
0.885	0.14516
0.890	0.16833
0.895	0.19432
0.900	0.22281
0.905	0.25447
0.910	0.28943
0.915	0.32776
0.920	0.36945
0.925	0.41446
0.930	0.46257
0.935	0.51337
0.940	0.56639
0.945	0.62112
0.950	0.67676
0.955	0.73193
0.960	0.78553
0.965	0.83514
0.970	0.88017
0.975	0.92217
0.980	0.95433
0.985	0.97783
0.990	0.99250
0.995	0.99893
1.000	1.00000

SAMPLE SIZE= 40	PASS/FAIL CRITERION= 38
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.885	0.04477
0.890	0.05419
0.895	0.06734
0.900	0.08047
0.905	0.09591
0.910	0.11397
0.915	0.13572
0.920	0.15945
0.925	0.18744
0.930	0.21926
0.935	0.25775
0.940	0.29934
0.945	0.34431
0.950	0.39514
0.955	0.45735
0.960	0.52095
0.965	0.58574
0.970	0.64154
0.975	0.71575
0.980	0.78954
0.985	0.87051
0.990	0.93579
0.995	0.97281
1.000	1.00000

SAMPLE SIZE= 40	PASS/FAIL CRITERION= 39
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.925	0.04423
0.930	0.05547
0.935	0.06739
0.940	0.08416
0.945	0.10525
0.950	[illegible]
0.955	0.15954
0.960	0.19537
0.965	0.24543
0.970	0.29571
0.975	0.36323
0.980	0.44170
0.985	0.54922
0.990	0.66837
0.995	0.81532
1.000	1.00000

SAMPLE SIZE= 46	PASS/FAIL CRITERION 36	SAMPLE SIZE= 46	PASS/FAIL CRITERION 37	SAMPLE SIZE= 46	PASS/FAIL CRITERION 38
TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.17253	0.750	0.09613	0.750	0.04461
0.755	0.19665	0.755	0.10735	0.755	0.05202
0.760	0.21636	0.760	0.12280	0.760	0.06045
0.765	0.23760	0.765	0.13816	0.765	0.07001
0.770	0.26262	0.770	0.15609	0.770	0.08079
0.775	0.28878	0.775	0.17521	0.775	0.09289
0.780	0.31641	0.780	0.19626	0.780	0.10646
0.785	0.34606	0.785	0.21900	0.785	0.12151
0.790	0.37635	0.790	0.24346	0.790	0.13821
0.795	0.40603	0.795	0.26962	0.795	0.15642
0.800	0.44072	0.800	0.29744	0.800	0.17682
0.805	0.47622	0.805	0.32699	0.805	0.19876
0.810	0.50836	0.810	0.35764	0.810	0.22279
0.815	0.54289	0.815	0.39022	0.815	0.24961
0.820	0.57759	0.820	0.42363	0.820	0.27630
0.825	0.61219	0.825	0.45969	0.825	0.30596
0.830	0.64643	0.830	0.49461	0.830	0.33735
0.835	0.68004	0.835	0.53014	0.835	0.37042
0.840	0.71277	0.840	0.56449	0.840	0.40505
0.845	0.74441	0.845	0.60312	0.845	0.44194
0.850	0.77453	0.850	0.63939	0.850	0.47817
0.855	0.80310	0.855	0.67509	0.855	0.51418
0.860	0.82986	0.860	0.70991	0.860	0.55478
0.865	0.85466	0.865	0.74363	0.865	0.59363
0.870	0.87736	0.870	0.77567	0.870	0.63238
0.875	0.89789	0.875	0.80511	0.875	0.67265
0.880	0.91620	0.880	0.83453	0.880	0.70404
0.885	0.93236	0.885	0.86052	0.885	0.74421
0.890	0.94624	0.890	0.88627	0.890	0.77875
0.895	0.95816	0.895	0.90585	0.895	0.81120
0.900	0.96851	0.900	0.92638	0.900	0.84149
0.905	0.97612	0.905	0.94053	0.905	0.86915
0.910	0.98262	0.910	0.95438	0.910	0.89403
0.915	0.98779	0.915	0.96575	0.915	0.91400
0.920	0.99157	0.920	0.97503	0.920	0.93500
0.925	0.99442	0.925	0.98236	0.925	0.95185
0.930	0.99648	0.930	0.98790	0.930	0.96427
0.935	0.99795	0.935	0.99213	0.935	0.97483
0.940	0.99876	0.940	0.99509	0.940	0.98240
0.945	0.99933	0.945	0.99711	0.945	0.98806
0.950	0.99967	0.950	0.99840	0.950	0.99335
0.955	0.99985	0.955	0.99919	0.955	0.99624
0.960	0.99994	0.960	0.99961	0.960	0.99805
0.965	0.99998	0.965	0.99985	0.965	0.99903
0.970	0.99999	0.970	0.99995	0.970	0.99964
0.975	1.00000	0.975	0.99999	0.975	0.99988
0.980	1.00000	0.980	1.00000	0.980	0.99997
0.985	1.00000	0.985	1.00000	0.985	1.00000
0.990	1.00000	0.990	1.00000	0.990	1.00000
0.995	1.00000	0.995	1.00000	0.995	1.00000
1.000	1.00000	1.000	1.00000	1.000	1.00000

SAMPLE SIZE: 45 TRUE VALUE OF P	PASS/FAIL CRITERION 39 PROBABILITY OF PASSING TEST
0.775	0.04199
0.780	0.04527
0.785	0.05762
0.790	0.06724
0.795	0.07756
0.800	0.09023
0.805	0.10199
0.810	0.11966
0.815	0.13444
0.820	0.15575
0.825	0.17489
0.830	0.20076
0.835	0.22576
0.840	0.23212
0.845	0.28764
0.850	0.32619
0.855	0.34[illegible]
0.860	0.37376
0.865	0.42124
0.870	0.46227
0.875	0.50777
0.880	0.54279
0.885	0.57357
0.890	0.62345
0.895	0.65721
0.900	0.72772
0.905	0.76719
0.910	0.78[illegible]
0.915	0.81[illegible]
0.920	0.85[illegible]
0.925	0.8[illegible]
0.930	0.91[illegible]
0.935	0.93[illegible]
0.940	0.94[illegible]
0.945	0.96433
0.950	0.97416
0.955	0.97[illegible]
0.960	0.98[illegible]
0.965	0.99256
0.970	0.99733
0.975	0.99916
0.980	0.99973
0.985	0.99996
0.990	0.99999
0.995	1.00000
1.000	1.00000

SAMPLE SIZE: 45 TRUE VALUE OF P	PASS/FAIL CRITERION 40 PROBABILITY OF PASSING TEST
0.805	0.04526
0.810	0.05536
0.815	0.06168
0.820	0.07339
0.825	0.08542
0.830	0.09951
0.835	0.11574
0.840	0.13293
0.845	0.15275
0.850	0.17491
0.855	0.19976
0.860	0.22913
0.865	0.25554
0.870	0.28753
0.875	0.31193
0.880	0.35[illegible]
0.885	0.3[illegible]
0.890	0.41[illegible]
0.895	0.4[illegible]
0.900	0.52716
0.905	0.57276
0.910	0.61876
0.915	0.66664
0.920	0.70992
0.925	0.75352
0.930	0.79567
0.935	0.83377
0.940	0.86981
0.945	0.90329
0.950	0.92727
0.955	0.94527
0.960	0.96342
0.965	0.97753
0.970	0.98909
0.975	0.99461
0.980	0.99794
0.985	0.99944
0.990	0.99991
0.995	0.99999
1.000	1.00000

SAMPLE SIZE: 46 TRUE VALUE OF P	PASS/FAIL CRITERION 41 PROBABILITY OF PASSING TEST
0.835	0.04728
0.840	0.05418
0.845	0.06452
0.850	0.07369
0.855	0.09227
0.860	0.10607
0.865	0.12447
0.870	0.14454
0.875	0.16752
0.880	0.19536
0.885	0.22409
0.890	0.25598
0.895	0.29045
0.900	0.32993
0.905	0.37189
0.910	0.41417
0.915	0.46291
0.920	0.50991
0.925	0.56047
0.930	0.61252
0.935	0.65449
0.940	0.71025
0.945	0.76428
0.950	0.81138
0.955	0.86077
0.960	0.89528
0.965	0.92824
0.970	0.95443
0.975	0.97519
0.980	0.98758
0.985	0.99538
0.990	0.99893
0.995	0.99992
1.000	1.00000

SAMPLE SIZE= 45 TRUE VALUE OF P	PASS/FAIL CRITERION= 42 PROBABILITY OF PASSING TEST	SAMPLE SIZE= 46 TRUE VALUE OF P	PASS/FAIL CRITERION= 43 PROBABILITY OF PASSING TEST	SAMPLE SIZE= 46 TRUE VALUE OF P	PASS/FAIL CRITERION= 44 PROBABILITY OF PASSING TEST
0.865	0.04787	0.895	0.04263	0.935	0.04059
0.870	0.05462	0.900	0.05237	0.940	0.06177
0.875	0.06709	0.905	0.06410	0.945	0.07862
0.880	0.07110	0.910	0.07822	0.950	0.09944
0.885	0.09656	0.915	0.09515	0.955	0.12594
0.890	0.11447	0.920	0.11529	0.960	0.15938
0.895	0.13521	0.925	0.13922	0.965	0.20125
0.900	0.15906	0.930	0.16746	0.970	0.25306
0.905	0.18627	0.935	0.20056	0.975	0.32004
0.910	0.21710	0.940	0.23916	0.980	0.40206
0.915	0.25261	0.945	0.28381	0.985	0.50656
0.920	0.29096	0.950	0.33696	0.990	0.63419
0.925	0.33416	0.955	0.39297	0.995	0.79007
0.930	0.38155	0.960	0.45790	1.000	1.00000
0.935	0.43325	0.965	0.52971		
0.940	0.48832	0.970	0.60734		
0.945	0.54429	0.975	0.68932		
0.950	0.59764	0.980	0.77287		
0.955	0.64932	0.985	0.85359		
0.960	0.73177	0.990	0.92536		
0.965	0.79179	0.995	0.97853		
0.970	0.84773	1.000	1.00000		
0.975	0.89763				
0.980	0.93599				
0.985	0.96390				
0.990	0.98362				
0.995	0.99548				
1.000	1.00000				

SAMPLE SIZE= 50	PASS/FAIL CRITERION 40	SAMPLE SIZE= 50	PASS/FAIL CRITERION 41	SAMPLE SIZE= 50	PASS/FAIL CRITERION 42
TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.16364	0.750	0.09146	0.750	0.04684
0.755	0.18425	0.755	0.10532	0.755	0.05811
0.760	0.20455	0.760	0.12062	0.760	0.06767
0.765	0.23267	0.765	0.13754	0.765	0.07744
0.770	0.25648	0.770	0.15627	0.770	0.08844
0.775	0.28397	0.775	0.17678	0.775	0.09977
0.780	0.31395	0.780	0.19916	0.780	0.11159
0.785	0.34376	0.785	0.22338	0.785	0.12921
0.790	0.37507	0.790	0.24952	0.790	0.14767
0.795	0.40924	0.795	0.27752	0.795	0.16730
0.800	0.44376	0.800	0.30733	0.800	0.19061
0.805	0.47709	0.805	0.33867	0.805	0.21482
0.810	0.51307	0.810	0.37178	0.810	0.24130
0.815	0.55162	0.815	0.40634	0.815	0.26959
0.820	0.58706	0.820	0.44219	0.820	0.30061
0.825	0.62444	0.825	0.47927	0.825	0.33298
0.830	0.65975	0.830	0.51678	0.830	0.36724
0.835	0.69654	0.835	0.55478	0.835	0.40322
0.840	0.72824	0.840	0.59294	0.840	0.44046
0.845	0.76751	0.845	0.63079	0.845	0.47926
0.850	0.79199	0.850	0.66818	0.850	0.51675
0.855	0.81976	0.855	0.70447	0.855	0.55579
0.860	0.84432	0.860	0.73955	0.860	0.59550
0.865	0.87963	0.865	0.77300	0.865	0.63457
0.870	0.89857	0.870	0.80463	0.870	0.67029
0.875	0.91611	0.875	0.83537	0.875	0.71462
0.880	0.92956	0.880	0.86044	0.880	0.75325
0.885	0.94447	0.885	0.88510	0.885	0.78583
0.890	0.95656	0.890	0.90686	0.890	0.82544
0.895	0.96497	0.895	0.92572	0.895	0.85647
0.900	0.97566	0.900	0.94213	0.900	0.87755
0.905	0.98225	0.905	0.95564	0.905	0.91293
0.910	0.98768	0.910	0.96717	0.910	0.92324
0.915	0.99146	0.915	0.97626	0.915	0.94118
0.920	0.99417	0.920	0.98318	0.920	0.95431
0.925	0.99663	0.925	0.98875	0.925	0.96439
0.930	0.99796	0.930	0.99260	0.930	0.97799
0.935	0.99875	0.935	0.99544	0.935	0.98529
0.940	0.99931	0.940	0.99731	0.940	0.99542
0.945	0.99966	0.945	0.99852	0.945	0.99536
0.950	0.99984	0.950	0.99924	0.950	0.99681
0.955	0.99993	0.955	0.99966	0.955	0.99836
0.960	0.99998	0.960	0.99985	0.960	0.99924
0.965	0.99999	0.965	0.99995	0.965	0.99964
0.970	1.00000	0.970	0.99998	0.970	0.99985
0.975	1.00000	0.975	1.00000	0.975	0.99994
0.980	1.00000	0.980	1.00000	0.980	0.99998
0.985	1.00000	0.985	1.00000	0.985	0.99999
0.990	1.00000	0.990	1.00000	0.990	1.00000
0.995	1.00000	0.995	1.00000	0.995	1.00000
0.999	1.00000	0.999	1.00000	0.999	1.00000

SAMPLE SIZE= 50 PASS/FAIL CRITERION= 43

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.775	0.04404
0.780	0.05551
0.785	0.06525
0.790	0.07638
0.795	0.08705
0.800	0.10348
0.805	0.11955
0.810	0.13764
0.815	0.15729
0.820	0.17987
0.825	0.20549
0.830	0.23161
0.835	0.25553
0.840	0.29194
0.845	0.32556
0.850	0.36130
0.855	0.39256
0.860	0.43337
0.865	0.47929
0.870	0.52159
0.875	0.56369
0.880	0.60652
0.885	0.64911
0.890	0.69096
0.895	0.73169
0.900	0.77023
0.905	0.80647
0.910	0.84017
0.915	0.87095
0.920	0.90313
0.925	0.92275
0.930	0.94169
0.935	0.95507
0.940	0.97128
0.945	0.97599
0.950	0.98421
0.955	0.99318
0.960	0.99638
0.965	0.99829
0.970	0.99936
0.975	0.99976
0.980	0.99994
0.985	0.99999
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 50 PASS/FAIL CRITERION= 44

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.795	0.04012
0.800	0.04933
0.805	0.05696
0.810	0.06733
0.815	0.07954
0.820	0.09196
0.825	0.10836
0.830	0.12591
0.835	0.14545
0.840	0.16771
0.845	0.19274
0.850	0.21975
0.855	0.24974
0.860	0.28139
0.865	0.31631
0.870	0.35175
0.875	0.39369
0.880	0.43636
0.885	0.47996
0.890	0.52196
0.895	0.56957
0.900	0.61012
0.905	0.65212
0.910	0.70719
0.915	0.75367
0.920	0.79147
0.925	0.83316
0.930	0.86495
0.935	0.89550
0.940	0.92236
0.945	0.94449
0.950	0.96232
0.955	0.97579
0.960	0.98569
0.965	0.99219
0.970	0.99636
0.975	0.99869
0.980	0.99952
0.985	0.99990
0.990	0.99999
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 50 PASS/FAIL CRITERION= 45

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.825	0.04787
0.830	0.05723
0.835	0.06455
0.840	0.08074
0.845	0.09537
0.850	0.11212
0.855	0.13119
0.860	0.15241
0.865	0.17716
0.870	0.20442
0.875	0.23[illegible]
0.880	0.26745
0.885	0.30417
0.890	0.34577
0.895	0.38619
0.900	0.43127
0.905	0.47851
0.910	0.52749
0.915	0.57524
0.920	0.62565
0.925	0.67953
0.930	0.72833
0.935	0.77635
0.940	0.82069
0.945	0.86057
0.950	0.89434
0.955	0.92655
0.960	0.95103
0.965	0.96959
0.970	0.98319
0.975	0.99187
0.980	0.99679
0.985	0.99938
0.990	0.99985
0.995	0.99999
1.000	1.00000

SAMPLE SIZE= 50 PASS/FAIL CRITERION= 46

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.850	0.04405
0.855	0.05546
0.860	0.06696
0.865	0.08025
.870	0.09577
0.875	0.11377
0.880	0.13451
0.885	0.15633
0.890	0.18041
0.895	0.21401
0.900	0.25019
0.905	0.28839
0.910	0.33036
0.915	0.37604
0.920	0.41530
0.925	0.47771
0.930	0.53276
0.935	0.58959
0.940	0.64738
0.945	0.70419
0.950	0.76041
0.955	0.81251
0.960	0.86087
0.965	0.90268
0.970	0.93724
0.975	0.96328
0.980	0.98226
0.985	0.99364
0.990	0.99549
0.995	0.99958
1.000	1.00000

SAMPLE SIZE= 50 PASS/FAIL CRITERION= 47

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.875	0.04176
0.880	0.05126
0.885	0.06210
0.890	0.07633
0.895	0.09255
0.900	0.11175
0.905	0.13426
0.910	0.16056
0.915	0.19099
0.920	0.22507
0.925	0.26563
0.930	0.31079
0.935	0.36096
0.940	0.41425
0.945	0.47077
0.950	0.54053
0.955	0.61703
0.960	0.67671
0.965	0.74020
0.970	0.81500
0.975	0.87302
0.980	0.92157
0.985	0.96075
0.990	0.98610
0.995	0.99796
1.000	1.00000

SAMPLE SIZE= 50 PASS/FAIL CRITERION= 48

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.905	0.04298
0.910	0.05324
0.915	0.06448
0.920	0.08271
0.925	0.10259
0.930	0.12849
0.935	0.15948
0.940	0.19709
0.945	0.23509
0.950	0.27963
0.955	0.33573
0.960	0.40540
0.965	0.47591
0.970	0.55526
0.975	0.64351
0.980	0.73577
0.985	0.82732
0.990	0.91056
0.995	0.97387
1.000	1.00000

SAMPLE SIZE= 50 TRUE VALUE OF P	PASS/FAIL CRITERION 49 PROBABILITY OF PASSING TEST
0.940	0.04633
0.945	0.05010
0.950	0.07646
0.955	0.10006
0.960	0.12909
0.965	0.16047
0.970	0.21007
0.975	[illegible]
0.980	0.36417
0.985	0.44969
0.990	0.64005
0.995	0.77051
1.000	1.00000

SAMPLE SIZE= 60 TRUE VALUE OF P	PASS/FAIL CRITERION 46 PROBABILITY OF PASSING TEST
0.750	0.16750
0.755	[illegible]
0.760	0.19206
0.765	0.21756
0.770	0.24679
0.775	0.27638
0.780	0.30079
0.785	0.33016
0.790	0.37412
0.795	[illegible]
0.800	[illegible]
0.805	0.48710
0.810	[illegible]
0.815	[illegible]
0.820	0.60461
0.825	0.64500
0.830	0.68021
0.835	0.72006
0.840	[illegible]
0.845	[illegible]
0.850	[illegible]
0.855	0.84707
0.860	0.87366
0.865	[illegible]
0.870	0.91496
0.875	0.93630
0.880	[illegible]
0.885	0.96136
0.890	0.97136
0.895	0.97927
0.900	[illegible]
0.905	[illegible]
0.910	[illegible]
0.915	0.99563
0.920	0.99766
0.925	[illegible]
0.930	0.99919
0.935	[illegible]
0.940	[illegible]
0.945	[illegible]
0.950	[illegible]
0.955	[illegible]
0.960	1.00000
0.965	1.00000
0.970	1.00000
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 60 TRUE VALUE OF P	PASS/FAIL CRITERION 49 PROBABILITY OF PASSING TEST
0.750	[illegible]
0.755	[illegible]
0.760	[illegible]
0.765	[illegible]
0.770	[illegible]
0.775	0.17775
0.780	[illegible]
0.785	[illegible]
0.790	[illegible]
0.795	[illegible]
0.800	[illegible]
0.805	[illegible]
0.810	[illegible]
0.815	[illegible]
0.820	[illegible]
0.825	[illegible]
0.830	[illegible]
0.835	[illegible]
0.840	[illegible]
0.845	[illegible]
0.850	[illegible]
0.855	[illegible]
0.860	[illegible]
0.865	[illegible]
0.870	[illegible]
0.875	[illegible]
0.880	[illegible]
0.885	[illegible]
0.890	[illegible]
0.895	[illegible]
0.900	[illegible]
0.905	[illegible]
0.910	[illegible]
0.915	[illegible]
0.920	[illegible]
0.925	[illegible]
0.930	0.99775
0.935	[illegible]
0.940	[illegible]
0.945	[illegible]
0.950	[illegible]
0.955	[illegible]
0.960	[illegible]
0.965	[illegible]
0.970	1.00000
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 60 PASS/FAIL CRITERION= 50

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.04517
0.755	0.05396
0.760	0.06615
0.765	0.07506
0.770	0.08932
0.775	0.10464
0.780	0.12160
0.785	0.14120
0.790	0.16091
0.795	0.18[illegible]7
0.800	0.21151
0.805	0.24197
0.810	0.27316
0.815	0.30[illegible]
0.820	0.3[illegible]
0.825	0.37[illegible]
0.830	0.41[illegible]
0.835	0.44[illegible]
0.840	0.50212
0.845	0.5[illegible]79
0.850	0.56770
0.855	0.63036
0.860	0.67226
0.865	0.71204
0.870	0.75173
0.875	0.79037
0.880	0.82750
0.885	0.86356
0.890	0.88131
0.895	0.90[illegible]
0.900	0.92693
0.905	0.94671
0.910	0.96[illegible]
0.915	0.97[illegible]
0.920	0.97[illegible]
0.925	0.98[illegible]
0.930	0.99[illegible]
0.935	0.99[illegible]
0.940	0.99713
0.945	0.99[illegible]
0.950	0.99[illegible]
0.955	0.99[illegible]
0.960	0.99[illegible]
0.965	0.99[illegible]
0.970	0.99[illegible]
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 60 PASS/FAIL CRITERION= 51

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.770	0.04[illegible]
0.775	0.0[illegible]
0.780	0.0[illegible]
0.785	0.07[illegible]
0.790	0.0[illegible]
0.795	0.10[illegible]
0.800	0.12[illegible]
0.805	0.14[illegible]
0.810	0.17[illegible]
0.815	0.19[illegible]
0.820	0.22[illegible]
0.825	0.2[illegible]
0.830	0.2[illegible]
0.835	0.3[illegible]
0.840	0.3[illegible]
0.845	0.4[illegible]
0.850	0.4[illegible]
0.855	0.4[illegible]
0.860	0.5[illegible]
0.865	0.57[illegible]
0.870	0.6[illegible]
0.875	0.6[illegible]
0.880	0.7[illegible]
0.885	0.7[illegible]
0.890	0.7[illegible]
0.895	0.8[illegible]
0.900	0.8[illegible]
0.905	0.8[illegible]
0.910	0.91[illegible]
0.915	0.93[illegible]
0.920	0.95[illegible]
0.925	0.9[illegible]
0.930	0.97[illegible]
0.935	0.9[illegible]
0.940	0.99[illegible]
0.945	0.99[illegible]
0.950	0.99[illegible]
0.955	0.99[illegible]
0.960	0.99[illegible]
0.965	0.99[illegible]
0.970	0.99[illegible]
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 60 PASS/FAIL CRITERION= 52

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.790	0.0[illegible]
0.795	0.0[illegible]
0.800	0.0[illegible]
0.805	0.0[illegible]
0.810	0.0[illegible]
0.815	0.11[illegible]
0.820	0.13[illegible]
0.825	0.1[illegible]
0.830	0.17[illegible]
0.835	0.2[illegible]
0.840	0.2[illegible]
0.845	0.2[illegible]
0.850	0.3[illegible]
0.855	0.3[illegible]
0.860	0.3[illegible]
0.865	0.4[illegible]
0.870	0.4[illegible]
0.875	0.5[illegible]
0.880	0.5[illegible]
0.885	0.6[illegible]
0.890	0.6[illegible]
0.895	0.7[illegible]
0.900	0.7[illegible]
0.905	0.7[illegible]
0.910	0.8[illegible]
0.915	0.8[illegible]
0.920	0.8[illegible]
0.925	0.9[illegible]
0.930	0.9[illegible]
0.935	0.9[illegible]
0.940	0.97[illegible]
0.945	0.9[illegible]
0.950	0.99[illegible]
0.955	0.99[illegible]
0.960	0.99[illegible]
0.965	0.99[illegible]
0.970	0.99[illegible]
0.975	0.99[illegible]
0.980	0.99[illegible]
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 60 PASS/FAIL CRITERION= 55

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.810	0.04601
0.815	0.05576
0.820	0.06728
0.825	0.08073
0.830	0.09634
0.835	0.11436
0.840	0.13498
0.845	0.15842
0.850	0.18484
0.855	0.21439
0.860	0.24716
0.865	0.28318
0.870	0.32222
0.875	0.36433
0.880	0.40917
0.885	0.45636
0.890	0.50539
0.895	0.55544
0.900	0.60548
0.905	0.65495
0.910	0.70439
0.915	0.75361
0.920	0.79821
0.925	0.83077
0.930	0.87525
0.935	0.90652
0.940	0.93226
0.945	0.95425
0.950	0.97331
0.955	0.98611
0.960	0.99311
0.965	0.99510
0.970	0.99790
0.975	0.99926
0.980	0.99959
0.985	0.99997
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 60 PASS/FAIL CRITERION= 56

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.830	0.04477
0.835	0.05472
0.840	0.06684
0.845	0.08047
0.850	0.09630
0.855	0.11578
0.860	0.13769
0.865	0.16277
0.870	0.19126
0.875	0.22327
0.880	0.25897
0.885	0.29836
0.890	0.34136
0.895	0.38776
0.900	0.43717
0.905	0.48912
0.910	0.54292
0.915	0.59776
0.920	0.65260
0.925	0.70642
0.930	0.75836
0.935	0.80633
0.940	0.85020
0.945	0.88873
0.950	0.92120
0.955	0.94751
0.960	0.96749
0.965	0.98166
0.970	0.99086
0.975	0.99615
0.980	0.99873
0.985	0.99971
0.990	0.99997
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 60 PASS/FAIL CRITERION= 58

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.850	0.04237
0.855	0.05236
0.860	0.06434
0.865	0.07865
0.870	0.09561
0.875	0.11555
0.880	0.13881
0.885	0.16572
0.890	0.19657
0.895	0.23160
0.900	0.27096
0.905	0.31469
0.910	0.36270
0.915	0.41469
0.920	0.47017
0.925	0.52852
0.930	0.58867
0.935	0.64911
0.940	0.70891
0.945	0.76631
0.950	0.81964
0.955	0.86743
0.960	0.90826
0.965	0.94124
0.970	0.96600
0.975	0.98290
0.980	0.99296
0.985	0.99793
0.990	0.99965
0.995	0.99994
1.000	1.00000

SAMPLE SIZE= 60	PASS/FAIL CRITERION= 56
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.875	0.04822
0.880	0.06013
0.885	0.07658
0.890	0.09190
0.895	0.11276
0.900	0.13764
0.905	0.16634
0.910	0.20000
0.915	0.23875
0.920	0.28206
0.925	0.33261
0.930	0.38732
0.935	0.44718
0.940	0.51128
0.945	0.57869
0.950	0.64720
0.955	0.71568
0.960	0.78134
0.965	0.84172
0.970	0.89426
0.975	0.93675
0.980	0.96781
0.985	0.98732
0.990	0.99649
0.995	0.99976
1.000	1.00000

SAMPLE SIZE= 60	PASS/FAIL CRITERION= 57
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.895	0.04160
0.900	0.05305
0.905	0.06716
0.910	0.08486
0.915	0.10565
0.920	0.13169
0.925	0.16277
0.930	0.19977
0.935	0.24136
0.940	0.29400
0.945	0.35264
0.950	0.41744
0.955	0.48968
0.960	0.56759
0.965	0.64917
0.970	0.73167
0.975	0.81046
0.980	0.88126
0.985	0.93852
0.990	0.97790
0.995	0.99556
1.000	1.00000

SAMPLE SIZE= 60	PASS/FAIL CRITERION= 58
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.920	0.04177
0.925	0.05496
0.930	0.07089
0.935	0.09160
0.940	0.11792
0.945	0.15076
0.950	0.19155
0.955	0.24159
0.960	0.30223
0.965	0.37460
0.970	0.45921
0.975	0.55671
0.980	0.66190
0.985	0.77277
0.990	0.87877
0.995	0.96344
1.000	1.00000

SAMPLE SIZE= 60	PASS/FAIL CRITERION= 54
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.950	[illegible]
0.955	0.06315
0.960	0.08615
0.965	0.11798
0.970	0.14082
0.975	0.21892
0.980	0.29798
0.985	0.40381
0.990	0.54736
0.995	0.74806
1.000	1.00000

SAMPLE SIZE= 70	PASS/FAIL CRITERION= 56
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.13536
0.755	0.15608
0.760	0.17872
0.765	0.20006
0.770	0.23592
0.775	0.26403
0.780	0.29850
0.785	0.33632
0.790	0.37206
0.795	0.41153
0.800	0.45241
0.805	0.49412
0.810	0.53606
0.815	0.57952
0.820	0.62104
0.825	0.66337
0.830	0.70150
0.835	0.74201
0.840	0.77826
0.845	0.81196
0.850	0.84283
0.855	0.87064
0.860	0.89530
0.865	0.91676
0.870	0.93510
0.875	0.95044
0.880	0.96301
0.885	0.97306
0.890	0.98090
0.895	0.98686
0.900	0.99124
0.905	0.99436
0.910	0.99652
0.915	0.99796
0.920	0.99886
0.925	0.99938
0.930	0.99969
0.935	0.99986
0.940	0.99994
0.945	0.99998
0.950	0.99999
0.955	1.00000
0.960	1.00000
0.965	1.00000
0.970	1.00000
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 70	PASS/FAIL CRITERION= 57
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.07909
0.755	0.09400
0.760	0.11102
0.765	0.13109
0.770	0.15276
0.775	0.17646
0.780	0.20266
0.785	0.23102
0.790	0.26148
0.795	0.29398
0.800	0.33605
0.805	0.37407
0.810	0.41386
0.815	0.45773
0.820	0.50099
0.825	0.54406
0.830	0.58685
0.835	0.63042
0.840	0.67502
0.845	0.71411
0.850	0.75024
0.855	0.79190
0.860	0.82072
0.865	0.85042
0.870	0.88378
0.875	0.90772
0.880	0.92824
0.885	0.94544
0.890	0.95956
0.895	0.97079
0.900	0.97904
0.905	0.98613
0.910	0.99093
0.915	0.99431
0.920	0.99650
0.925	0.99806
0.930	0.99896
0.935	0.99948
0.940	0.99976
0.945	0.99991
0.950	0.99996
0.955	0.99999
0.960	1.00000
0.965	1.00000
0.970	1.00000
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 70	PASS/FAIL CRITERION= 58	SAMPLE SIZE= 70	PASS/FAIL CRITERION= 59	SAMPLE SIZE= 70	PASS/FAIL CRITERION= 60
TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.04396	0.765	0.04340	0.785	0.04732
0.755	0.05[illegible]	0.770	0.05[illegible]	0.790	0.05777
0.760	0.06[illegible]	0.775	0.06120	0.795	0.07018
0.765	0.07713	0.780	0.07900	0.800	0.08054
0.770	0.09194	0.785	0.08894	0.805	0.10236
0.775	0.1[illegible]	0.790	0.10946	0.810	0.11863
0.780	0.12826	0.795	0.12461	0.815	0.14271
0.785	0.15031	0.800	0.14679	0.820	0.14772
0.790	0.17457	0.805	0.17194	0.825	0.19[illegible]
0.795	[illegible]	0.810	0.19917	0.830	0.22[illegible]
0.800	0.[illegible]	0.815	0.22971	0.835	0.26164
0.805	0.26434	0.820	0.26322	0.840	0.29095
0.810	0.29[illegible]	0.825	0.29957	0.845	0.33961
0.815	0.33[illegible]	0.830	0.33[illegible]	0.850	0.3[illegible]
0.820	0.37757	0.835	0.38015	0.855	0.42087
0.825	0.41966	0.840	0.42381	0.860	0.47345
0.830	0.46133	0.845	0.46714	0.865	0.52615
0.835	0.51910	0.850	0.51577	0.870	0.57350
0.840	0.55351	0.855	0.56308	0.875	0.62275
0.845	0.[illegible]	0.860	0.61024	0.880	0.67121
0.850	0.64399	0.865	0.65467	0.885	0.71063
0.855	0.68782	0.870	0.70206	0.890	0.76265
0.860	0.7[illegible]	0.875	0.74625	0.895	0.80379
0.865	0.7[illegible]	0.880	0.78903	0.900	0.84164
0.870	0.80461	0.885	0.82321	0.905	0.87405
0.875	0.84049	0.890	0.85703	0.910	0.90402
0.880	0.87188	0.895	0.88692	0.915	0.92886
0.885	0.89793	0.900	0.91273	0.920	0.94659
0.890	0.92[illegible]	0.905	0.93[illegible]	0.925	0.96661
0.895	0.94811	0.910	0.95226	0.930	0.97645
0.900	0.95534	0.915	0.96634	0.935	0.98519
0.905	0.96856	0.920	0.97721	0.940	0.99122
0.910	0.97878	0.925	0.98520	0.945	0.99515
0.915	0.98355	0.930	0.99005	0.950	0.99753
0.920	0.98670	0.935	0.99454	0.955	0.99886
0.925	0.99[illegible]	0.940	0.99708	0.960	0.9995[illegible]
0.930	0.99477	0.945	0.99852	0.965	0.99977
0.935	0.99825	0.950	0.99932	0.970	0.99993
0.940	0.99917	0.955	0.99972	0.975	0.99999
0.945	0.99959	0.960	0.99990	0.980	1.00000
0.950	0.99983	0.965	0.99997	0.985	1.00000
0.955	0.99926	0.970	0.99799	0.990	1.00000
0.960	0.99998	0.975	1.00000	0.995	1.00000
0.965	0.99999	0.980	1.00000	1.000	1.00000
0.970	1.00000	0.985	1.00000		
0.975	1.00000	0.990	1.00000		
0.980	1.00000	0.995	1.00000		
0.985	1.00000	1.000	1.00000		
0.990	1.00000				
0.995	1.00000				
1.000	1.00000				

SAMPLE SIZE= 73 TRUE VALUE OF P	PASS/FAIL CRITERION= 61 PROBABILITY OF PASSING TEST
0.800	0.04371
0.805	0.05377
0.810	0.06973
0.815	0.07726
0.820	0.09539
0.825	0.11563
0.830	0.13332
0.835	0.16295
0.840	0.19169
0.845	0.22363
0.850	0.25793
0.855	0.29764
0.860	0.33972
0.865	0.38479
0.870	0.43267
0.875	0.48221
0.880	0.53353
0.885	0.58533
0.890	0.63731
0.895	0.68763
0.900	0.73535
0.905	0.78201
0.910	0.82427
.925	0.86177
0.920	0.89466
0.925	0.92262
0.930	0.94525
0.935	0.96266
0.940	0.97618
0.945	0.98547
0.950	0.99187
0.955	0.99559
0.960	0.99811
0.965	0.99926
0.970	0.99976
0.975	0.99994
0.980	0.99999
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 79 TRUE VALUE OF P	PASS/FAIL CRITERION= 62 PROBABILITY OF PASSING TEST
0.820	0.04923
0.825	0.05872
0.830	.07441
0.835	0.09141
0.840	0.11959
0.845	0.13345
0.850	0.15924
0.855	0.18833
0.860	0.21545
0.865	0.25514
0.870	0.29547
0.875	0.33942
0.880	0.38675
0.885	0.43723
0.890	0.48767
0.895	0.54352
0.900	0.59455
0.905	0.64548
0.910	0.70971
0.915	0.75163
0.920	0.80455
0.925	0.84771
0.930	0.88459
0.935	0.91626
0.940	0.94197
0.945	0.96165
0.950	0.97644
0.955	0.98674
0.960	0.99322
0.965	0.99692
0.970	0.99862
0.975	0.99954
0.980	0.99992
0.985	0.99998
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 76 TRUE VALUE OF P	PASS/FAIL CRITERION= 63 PROBABILITY OF PASSING TEST
0.835	0.04411
0.840	0.05437
0.845	0.06511
0.850	0.08383
0.855	0.10249
0.860	0.12427
0.865	0.14972
0.870	0.17906
0.875	0.21167
0.880	0.25016
0.885	0.29224
0.890	0.33529
0.895	0.38354
0.900	0.43581
0.905	0.48951
0.910	0.54524
0.915	0.61465
0.920	0.67175
0.925	0.72942
0.930	0.78253
0.935	0.83107
0.940	0.87352
0.945	0.91025
0.950	0.93965
0.955	0.96213
0.960	0.97832
0.965	0.98575
0.970	0.99437
0.975	0.99815
0.980	0.99944
0.985	0.99991
0.990	0.99999
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 70	PASS/FAIL CRITERION= 64
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.855	0.04647
0.860	0.06083
0.865	0.07581
0.870	0.09382
0.875	0.11520
0.880	0.14061
0.885	0.17018
0.890	0.20633
0.895	0.24331
0.900	0.28722
0.905	0.33483
0.910	0.38949
0.915	0.44480
0.920	0.50262
0.925	0.57053
0.930	0.63625
0.935	0.69708
0.940	0.75739
0.945	0.81313
0.950	0.86277
0.955	0.90646
0.960	0.93861
0.965	0.96419
0.970	0.98136
0.975	0.99182
0.980	0.99719
0.985	0.99936
0.990	0.99992
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 70	PASS/FAIL CRITERION= 65
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.870	0.04117
0.875	0.05240
0.880	0.06444
0.885	0.08354
0.890	0.10479
0.895	0.12976
0.900	0.15879
0.905	0.19354
0.910	0.23368
0.915	0.28067
0.920	0.33211
0.925	0.38945
0.930	0.45235
0.935	0.51916
0.940	0.58544
0.945	0.65731
0.950	0.72796
0.955	0.79247
0.960	0.85155
0.965	0.90136
0.970	0.94875
0.975	0.96552
0.980	0.98677
0.985	0.99549
0.990	0.99929
0.995	0.99997
1.000	1.00000

SAMPLE SIZE= 70	PASS/FAIL CRITERION= 66
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.890	0.04296
0.895	0.05551
0.900	0.07123
0.905	0.09075
0.910	0.11475
0.915	0.14396
0.920	0.17962
0.925	0.22043
0.930	0.26929
0.935	0.32524
0.940	0.38851
0.945	0.45943
0.950	0.53387
0.955	0.61272
0.960	0.69209
0.965	0.77333
0.970	0.84127
0.975	0.90167
0.980	0.94520
0.985	0.97378
0.990	0.99457
0.995	0.99756
1.000	1.00000

SAMPLE SIZE= 70 PASS/FAIL CRITERION= 67

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.910	0.04204
0.915	0.05646
0.920	0.07376
0.925	0.09619
0.930	0.12618
0.935	0.15878
0.940	0.20135
0.945	0.25269
0.950	0.31376
0.955	0.38490
0.960	0.45556
0.965	0.55443
0.970	0.64924
0.975	0.76443
0.980	0.83445
0.985	0.91167
0.990	0.96645
0.995	0.99447
1.000	1.00000

SAMPLE SIZE= 70 PASS/FAIL CRITERION= 68

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.935	0.05312
0.940	0.07191
0.945	0.09673
0.950	0.12921
0.955	0.17122
0.960	0.22600
0.965	0.29226
0.970	0.37551
0.975	0.47099
0.980	0.59044
0.985	0.71724
0.990	0.84472
0.995	0.95173
1.000	1.00000

SAMPLE SIZE= 70 PASS/FAIL CRITERION= 69

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.960	0.05741
0.965	0.08259
0.970	0.11856
0.975	0.16945
0.980	0.24312
0.985	0.34717
0.990	0.49484
0.995	0.72487
1.000	1.00000

SAMPLE SIZE= 80	PASS/FAIL CRITERION= 64	SAMPLE SIZE= 80	PASS/FAIL CRITERION= 65	SAMPLE SIZE= 80	PASS/FAIL CRITERION= 66
TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.12076	0.750	0.07309	0.750	0.04218
0.755	0.14233	0.755	0.09013	0.755	0.05187
0.760	0.16663	0.760	0.10663	0.760	0.06346
0.765	0.19366	0.765	0.12667	0.765	0.07712
0.770	0.22351	0.770	0.14963	0.770	0.09306
0.775	0.25616	0.775	0.17502	0.775	0.11150
0.780	0.29152	0.780	0.20394	0.780	0.13206
0.785	0.32961	0.785	0.23551	0.785	0.15667
0.790	0.36960	0.790	0.26738	0.790	0.18369
0.795	0.41175	0.795	0.30094	0.795	0.21301
0.800	0.45567	0.800	0.34628	0.800	0.24701
0.805	0.50038	0.805	0.38832	0.805	0.28386
0.810	0.54671	0.810	0.43028	0.810	0.32230
0.815	0.59113	0.815	0.47771	0.815	0.36414
0.820	0.63556	0.820	0.52406	0.820	0.40819
0.825	0.67965	0.825	0.57076	0.825	0.45410
0.830	0.72150	0.830	0.61714	0.830	0.50133
0.835	0.76125	0.835	0.66267	0.835	0.54829
0.840	0.79818	0.840	0.70640	0.840	0.59730
0.845	0.83201	0.845	0.74836	0.845	0.64440
0.850	0.86247	0.850	0.78730	0.850	0.69070
0.855	0.88937	0.855	0.82158	0.855	0.73470
0.860	0.91272	0.860	0.85549	0.860	0.77606
0.865	0.93256	0.865	0.88638	0.865	0.81418
0.870	0.94920	0.870	0.90981	0.870	0.84869
0.875	0.96257	0.875	0.93038	0.875	0.87909
0.880	0.97296	0.880	0.94776	0.880	0.90506
0.885	0.98109	0.885	0.96187	0.885	0.92676
0.890	0.98718	0.890	0.97295	0.890	0.94479
0.895	0.99160	0.895	0.98141	0.895	0.96167
0.900	0.99470	0.900	0.98765	0.900	0.97255
0.905	0.99678	0.905	0.99211	0.905	0.98198
0.910	0.99816	0.910	[illegible]	0.910	0.98833
0.915	0.99897	0.915	0.99717	0.915	0.99277
0.920	0.99946	0.920	0.99843	0.920	0.99573
0.925	0.99974	0.925	0.99910	0.925	0.99761
0.930	0.99988	0.930	0.99958	0.930	0.99875
0.935	0.99995	0.935	0.99982	0.935	0.99939
0.940	0.99998	0.940	0.99993	0.940	0.99973
0.945	0.99999	0.945	0.99997	0.945	0.99989
0.950	1.00000	0.950	0.99999	0.950	0.99996
0.955	1.00000	0.955	1.00000	0.955	0.99999
0.960	1.00000	0.960	1.00000	0.960	1.00000
0.965	1.00000	0.965	1.00000	0.965	1.00000
0.970	1.00000	0.970	1.00000	0.970	1.00000
0.975	1.00000	0.975	1.00000	0.975	1.00000
0.980	1.00000	0.980	1.00000	0.980	1.00000
0.985	1.00000	0.985	1.00000	0.985	1.00000
0.990	1.00000	0.990	1.00000	0.990	1.00000
0.995	1.00000	0.995	1.00000	0.995	1.00000
1.000	1.00000	1.000	1.00000	1.000	1.00000

SAMPLE SIZE= 88 PASS/FAIL CRITERION= 67

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.765	0.04342
0.770	0.05343
0.775	0.06578
0.780	0.08012
0.785	0.09698
0.790	0.11634
0.795	0.13266
0.800	0.16485
0.805	0.19063
0.810	0.22446
0.815	0.25968
0.820	0.29789
0.825	0.33938
0.830	0.38315
0.835	0.42948
0.840	0.47762
0.845	0.52459
0.850	0.57622
0.855	0.62555
0.860	0.67381
0.865	0.72022
0.870	0.76485
0.875	0.80444
0.880	0.84151
0.885	0.87421
0.890	0.90256
0.895	0.92658
0.900	0.94617
0.905	0.96183
0.910	0.97390
0.915	0.98205
0.920	0.98924
0.925	0.99350
0.930	0.99637
0.935	0.99818
0.940	0.99937
0.945	0.99954
0.950	0.99984
0.955	0.99994
0.960	0.99998
0.965	1.00000
0.970	1.00000
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 89 PASS/FAIL CRITERION= 68

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.780	0.04453
0.785	0.05510
0.790	0.06790
0.795	0.08295
0.800	0.10040
0.805	0.12110
0.810	0.14469
0.815	0.17155
0.820	0.20183
0.825	0.23560
0.830	0.27283
0.835	0.31341
0.840	0.35709
0.845	0.40351
0.850	0.45219
0.855	0.50251
0.860	0.55376
0.865	0.60513
0.870	0.65577
0.875	0.70483
0.880	0.75136
0.885	0.79478
0.890	0.83415
0.895	0.86920
0.900	0.89956
0.905	0.92512
0.910	0.94599
0.915	0.96245
0.920	0.97496
0.925	0.98437
0.930	0.99030
0.935	0.99455
0.940	0.99712
0.945	0.99863
0.950	0.99939
0.955	0.99976
0.960	0.99992
0.965	0.99998
0.970	1.00000
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 90 PASS/FAIL CRITERION= 69

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.795	0.04518
0.800	0.05646
0.805	0.06975
0.810	0.08563
0.815	0.10409
0.820	0.12573
0.825	0.15066
0.830	0.17917
0.835	0.21133
0.840	0.24723
0.845	0.28683
0.850	0.32996
0.855	0.37634
0.860	0.42551
0.865	0.47689
0.870	0.52976
0.875	0.58323
0.880	0.63640
0.885	0.68820
0.890	0.73767
0.895	0.78455
0.900	0.82662
0.905	0.86431
0.910	0.89673
0.915	0.92427
0.920	0.94661
0.925	0.96366
0.930	0.97683
0.935	0.98567
0.940	0.99180
0.945	0.99566
0.950	0.99790
0.955	0.99909
0.960	0.99964
0.965	0.99989
0.970	0.99997
0.975	0.99999
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 80	PASS/FAIL CRITERION= 70	SAMPLE SIZE= 80	PASS/FAIL CRITERION= 71	SAMPLE SIZE= 80	PASS/FAIL CRITERION= 72
TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.810	0.04690	0.825	0.04680	0.840	0.04580
0.815	0.05730	0.830	0.05700	0.845	0.05700
0.820	0.07126	0.835	0.07228	0.850	0.07272
0.825	0.08777	0.840	0.08987	0.855	0.09176
0.832	0.10730	0.845	0.11010	0.860	0.11234
0.835	0.13015	0.850	0.13425	0.865	0.13700
0.843	0.15659	0.855	0.16233	0.870	0.16777
0.846	0.18606	0.860	0.19450	0.875	0.20259
0.850	0.22112	0.865	0.23122	0.880	0.24165
0.855	0.25942	0.870	0.27228	0.885	0.28590
0.860	0.30173	0.875	0.31765	0.890	0.33492
0.865	0.34776	0.880	0.36700	0.895	0.38634
0.870	0.39723	0.885	0.42099	0.900	0.44556
0.875	0.44950	0.890	0.47599	0.905	0.50570
0.880	0.50302	0.895	0.53385	0.910	0.56761
0.885	0.55950	0.900	0.59168	0.915	0.62996
0.890	0.61547	0.905	0.65114	0.920	0.69111
0.895	0.67047	0.910	0.70796	0.925	0.74952
0.900	0.72346	0.915	0.76173	0.930	0.80387
0.905	0.77328	0.920	0.81125	0.935	0.85104
0.910	0.81896	0.925	0.85542	0.940	0.89325
0.915	0.85967	0.930	0.89347	0.945	0.92714
0.920	0.89491	0.935	0.92495	0.950	0.95301
0.925	0.92612	0.940	0.94965	0.955	0.97248
0.930	0.94764	0.945	0.96947	0.960	0.98526
0.935	0.96549	0.950	0.98160	0.965	0.99324
0.940	0.97871	0.955	0.99018	0.970	0.99721
0.945	0.98771	0.960	0.99532	0.975	0.99911
0.950	0.99347	0.965	0.99806	0.980	0.99979
0.955	0.99684	0.970	0.99933	0.985	0.99997
0.960	0.99867	0.975	0.99978	0.990	1.00000
0.965	0.99953	0.980	0.99997	0.995	1.00000
0.970	0.99986	0.985	1.00000	1.000	1.00000
0.975	0.99997	0.990	1.00000		
0.980	1.00000	0.995	1.00000		
0.985	1.00000	1.000	1.00000		
0.990	1.00000				
0.995	1.00000				
1.000	1.00000				

SAMPLE SIZE: 80	PASS/FAIL CRITERION: 73
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.855	0.00461
0.860	0.05698
0.865	0.07235
0.870	0.09112
0.875	0.11579
0.880	0.14606
0.885	0.17273
0.890	0.20963
0.895	0.25219
0.900	0.30045
0.905	0.35365
0.910	0.41213
0.915	0.47646
0.920	0.53977
0.925	0.60438
0.930	0.67267
0.935	0.73440
0.940	0.79511
0.945	0.84933
0.950	0.89471
0.955	0.93129
0.960	0.95283
0.965	0.97787
0.970	0.98969
0.975	0.99695
0.980	0.99886
0.985	0.99979
0.990	0.99998
0.995	1.00000
1.000	1.00000

SAMPLE SIZE: 80	PASS/FAIL CRITERION: 74
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.870	0.04240
0.875	0.05519
0.880	0.07091
0.885	0.09035
0.890	0.11410
0.895	0.14277
0.900	0.17692
0.905	0.21702
0.910	0.26341
0.915	0.31415
0.920	0.37522
0.925	0.43939
0.930	0.50417
0.935	0.57178
0.940	0.64216
0.945	0.72287
0.950	0.78522
0.955	0.84042
0.960	0.89151
0.965	0.93531
0.970	0.96653
0.975	0.98479
0.980	0.99456
0.985	0.99567
0.990	0.99994
0.995	1.00000
1.000	1.00000

SAMPLE SIZE: 60	PASS/FAIL CRITERION: 75
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.890	0.05213
0.895	0.06002
0.900	0.08797
0.905	0.11275
0.910	0.14311
0.915	0.17901
0.920	0.22350
0.925	0.27642
0.930	0.33333
0.935	[illegible]
0.940	0.47174
0.945	0.54003
0.950	0.62023
0.955	0.70826
0.960	0.78358
0.965	0.85105
0.970	0.90721
0.975	0.94463
0.980	0.97764
0.985	[illegible]
0.990	0.99871
0.995	0.99996
1.000	1.00000

SAMPLE SIZE= 80 PASS/FAIL CRITERION= 76

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.905	0.04739
0.910	0.06309
0.915	0.09326
0.920	[illegible]
0.925	[illegible]
0.930	0.18251
0.935	0.22455
0.940	0.26579
0.945	0.35351
[illegible]	[illegible]
[illegible]	[illegible]
0.960	0.60165
0.965	0.69276
0.970	0.76967
0.975	0.85163
0.980	0.92314
0.985	0.96751
0.990	0.99134
0.995	0.99927
1.000	1.00000

SAMPLE SIZE= 80 PASS/FAIL CRITERION= 77

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.920	0.04630
0.925	[illegible]
0.933	[illegible]
0.935	[illegible]
0.940	[illegible]
0.945	0.17715
[illegible]	[illegible]
0.955	[illegible]
0.960	[illegible]
0.965	[illegible]
0.970	[illegible]
0.975	[illegible]
[illegible]	[illegible]
0.985	0.88021
0.990	[illegible]
0.995	[illegible]
1.000	1.00000

SAMPLE SIZE= 80 PASS/FAIL CRITERION= 78

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.940	0.04325
0.945	[illegible]
0.950	[illegible]
0.955	[illegible]
0.960	[illegible]
[illegible]	0.22964
[illegible]	0.30381
0.975	[illegible]
[illegible]	[illegible]
0.985	[illegible]
0.990	[illegible]
0.995	[illegible]
1.000	1.00000

SAMPLE SIZE= 80 PASS/FAIL CRITERION= 79

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.965	0.05783
0.970	0.08746
0.975	0.13194
0.980	0.19866
0.985	0.29847
0.990	0.44752
0.995	0.66966
1.000	1.00000

SAMPLE SIZE= 90 PASS/FAIL CRITERION= 72

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.10956
0.755	0.13103
0.760	0.15550
0.765	0.19367
0.770	0.21361
0.775	0.24771
0.780	0.28467
0.785	0.32492
0.790	0.36496
0.795	0.41162
0.800	0.45601
0.805	0.50554
0.810	0.55[illegible]
0.815	0.60164
0.820	0.64875
0.825	0.69431
0.830	0.73771
0.835	0.77831
0.840	0.81546
0.845	0.84916
0.850	0.87915
0.855	0.90495
0.860	0.92691
0.865	0.94556
0.870	0.95973
0.875	0.97127
0.880	0.98016
0.885	0.98664
0.890	0.99136
0.895	0.99460
0.900	0.99677
0.905	0.99815
0.910	0.99900
0.915	0.99948
0.920	0.99975
0.925	0.99988
0.930	0.99995
0.935	0.99998
0.940	0.99999
0.945	1.00000
0.950	1.00000
0.955	1.00000
0.960	1.00000
0.965	1.00000
0.970	1.00000
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 90 PASS/FAIL CRITERION= 73

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.750	0.06053
0.755	0.08756
0.760	0.10156
0.765	0.12190
0.770	0.14561
0.775	0.17267
0.780	0.20251
0.785	0.23591
0.790	0.27294
0.795	0.31227
0.800	0.35433
0.805	0.39946
0.810	0.44497
0.815	0.49523
0.820	0.54538
0.825	0.59156
0.830	0.64272
0.835	0.68991
0.840	0.73540
0.845	0.77576
0.850	0.81436
0.855	0.84910
0.860	0.87718
0.865	0.90635
0.870	0.92665
0.875	0.94722
0.880	0.96176
0.885	0.97316
0.890	0.98160
0.895	0.98779
0.900	0.99213
0.905	0.99544
0.910	0.99740
0.915	0.99865
0.920	0.99937
0.925	0.99965
0.930	0.99985
0.935	0.99994
0.940	0.99998
0.945	0.99999
0.950	1.00000
0.955	1.00000
0.960	1.00000
0.965	1.00000
0.970	1.00000
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 90 PASS/FAIL CRITERION= 74

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.755	0.04994
0.760	0.06197
0.765	0.07429
0.770	0.09317
0.775	0.11206
0.780	0.13540
0.785	0.16158
0.790	0.19095
0.795	0.22376
0.800	0.26005
0.805	0.29934
0.810	0.34219
0.815	0.38796
0.820	0.43519
0.825	0.48443
0.830	0.53449
0.835	0.58516
0.840	0.63510
0.845	0.68362
0.850	0.72896
0.855	0.77340
0.860	0.81332
0.865	0.84926
0.870	0.88026
0.875	0.91096
0.880	0.93551
0.885	0.95157
0.890	0.96494
0.895	0.97543
0.900	0.98358
0.905	0.98963
0.910	0.99379
0.915	0.99636
0.920	0.99801
0.925	0.99899
0.930	0.99951
0.935	0.99979
0.940	0.99991
0.945	0.99997
0.950	0.99999
0.955	1.00000
0.960	1.00000
0.965	1.00000
0.970	1.00000
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 90 PASS/FAIL CRITERION= 75

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.765	0.04456
0.770	0.05571
0.775	0.06909
0.780	0.08495
0.785	0.10349
0.790	0.12946
0.795	0.15053
0.800	0.17909
0.805	0.21124
0.810	0.24702
0.815	0.28433
0.820	0.32339
0.825	0.37467
0.830	0.42290
0.835	0.47189
0.840	0.52154
0.845	0.57045
0.850	0.62776
0.855	0.67816
0.860	0.72419
0.865	0.77125
0.870	0.81264
0.875	0.84702
0.880	0.88262
0.885	0.91028
0.890	0.93345
0.895	0.95216
0.900	0.96673
0.905	0.97775
0.910	0.98571
0.915	0.99124
0.920	0.99491
0.925	0.99721
0.930	0.99857
0.935	0.99932
0.940	0.99971
0.945	0.99989
0.950	0.99996
0.955	0.99999
0.960	1.00000
0.965	1.00000
0.970	1.00000
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 90 PASS/FAIL CRITERION= 76

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.780	0.04957
0.785	0.06197
0.790	0.07604
0.795	0.09449
0.800	0.11527
0.805	0.13929
0.810	0.16475
0.815	0.19251
0.820	0.22184
0.825	0.27254
0.830	0.31517
0.835	0.36113
0.840	0.40999
0.845	0.46115
0.850	0.51387
0.855	0.56732
0.860	0.62057
0.865	0.67262
0.870	0.72253
0.875	0.76938
0.880	0.81838
0.885	0.85891
0.890	0.89485
0.895	0.91311
0.900	0.93643
0.905	0.95637
0.910	0.96970
0.915	0.98016
0.920	0.98740
0.925	0.99294
0.930	0.99611
0.935	0.99801
0.940	0.99924
0.945	0.99960
0.950	0.99985
0.955	0.99995
0.960	0.99999
0.965	1.00000
0.970	1.00000
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 90	PASS/FAIL CRITERION= 77
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.790	0.04358
0.795	0.05497
0.800	0.06575
0.805	0.08526
0.810	0.10487
0.815	0.12725
0.820	0.15243
0.825	0.18500
0.830	0.21956
0.835	0.25812
0.840	0.29954
0.845	0.34635
0.850	0.37633
0.855	0.42358
0.860	0.50259
0.865	0.55772
0.870	0.61209
0.875	0.66781
0.880	0.71990
0.885	0.76784
0.890	0.81263
0.895	0.85264
0.900	0.88735
0.905	0.91634
0.910	0.94645
0.915	0.95712
0.920	0.97317
0.925	0.98326
0.930	0.99015
0.935	[illegible]9457
0.940	0.[illegible]723
0.945	0.99871
0.950	0.99946
0.955	0.99993
0.960	0.99996
0.965	0.99998
0.970	1.00000
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 90	PASS/FAIL CRITERION= 78
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.805	0.04012
0.810	0.06077
0.815	0.07609
0.820	0.09464
0.825	0.11623
0.830	0.14178
0.835	0.17126
0.840	0.20497
0.845	0.24301
0.850	0.28532
0.855	0.33172
0.860	0.38101
0.865	0.43502
0.870	0.48850
0.875	0.54757
0.880	0.60487
0.885	0.66138
0.890	0.71566
0.895	0.76673
0.900	0.81361
0.905	0.85516
0.910	0.89185
0.915	0.92097
0.920	0.94490
0.925	0.96343
0.930	0.97695
0.935	0.98633
0.940	0.99265
0.945	0.99617
0.950	0.99826
0.955	0.99928
0.960	0.99975
0.965	0.99993
0.970	0.99998
0.975	1.00000
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 90	PASS/FAIL CRITERION= 79
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.815	0.04144
0.820	0.05252
0.825	0.06497
0.830	0.08401
0.835	0.10445
0.840	0.12066
0.845	0.15731
0.850	0.18977
0.855	0.22712
0.860	0.26911
0.865	0.31543
0.870	0.36627
0.875	0.42057
0.880	0.47773
0.885	0.53675
0.890	0.59646
0.895	0.65549
0.900	0.71251
0.905	0.76617
0.910	0.81318
0.915	0.85249
0.920	0.89573
0.925	0.92427
0.930	0.95032
0.935	0.96833
0.940	0.98103
0.945	0.98853
0.950	0.99471
0.955	0.99760
0.960	0.99905
0.965	0.99969
0.970	0.99992
0.975	0.99979
0.980	1.00000
0.985	1.00000
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 90 TRUE VALUE OF P	PASS/FAIL CRITERION= 80 PROBABILITY OF PASSING TEST	SAMPLE SIZE= 90 TRUE VALUE OF P	PASS/FAIL CRITERION= 81 PROBABILITY OF PASSING TEST	SAMPLE SIZE= 90 TRUE VALUE OF P	PASS/FAIL CRITERION= 82 PROBABILITY OF PASSING TEST
0.830	0.04527	0.845	0.04917	0.855	0.04653
0.835	0.05796	0.850	0.06324	0.860	0.05395
0.840	0.07369	0.855	0.08054	0.865	0.06843
0.845	0.09250	0.860	0.10172	0.870	0.08793
0.850	0.11532	0.865	0.12716	0.875	0.11155
0.855	0.14230	0.870	0.15736	0.880	0.14066
0.860	0.17302	0.875	0.19271	0.885	0.17599
0.865	0.21039	0.880	0.23367	0.890	0.21375
0.870	0.25107	0.885	0.27975	0.895	0.25958
0.875	0.29536	0.890	0.33137	0.900	0.31149
0.880	0.34456	0.895	0.38793	0.905	0.36916
0.885	0.40456	0.900	0.44866	0.910	0.43190
0.890	0.46303	0.905	0.51269	0.915	0.49960
0.895	0.52512	0.910	0.57882	0.920	0.56776
0.900	0.58753	0.915	0.64357	0.925	0.63766
0.905	0.64964	0.920	0.70730	0.930	0.70563
0.910	0.70469	0.925	0.76733	0.935	0.76967
0.915	0.76627	0.930	0.82186	0.940	0.82778
0.920	0.81706	0.935	0.86559	0.945	0.87779
0.925	0.86327	0.940	0.90919	0.950	0.91871
0.930	0.92167	0.945	0.94096	0.955	0.95000
0.935	0.93273	0.950	0.96364	0.960	0.97211
0.940	0.95650	0.955	0.97975	0.965	0.98627
0.945	0.97306	0.960	0.98878	0.970	0.99426
0.950	0.98540	0.965	0.99567	0.975	0.99868
0.955	0.99271	0.970	0.99766	0.980	0.99954
0.960	0.99677	0.975	0.99957	0.985	0.99993
0.965	0.99877	0.980	0.99992	0.990	1.00000
0.970	0.99952	0.985	0.99999	0.995	1.00000
0.975	0.99992	0.990	1.00000	1.000	1.00000
0.980	0.99999	0.995	1.00000		
0.985	1.00000	1.000	1.00000		
0.990	1.00000				
0.995	1.00000				
1.000	1.00000				

SAMPLE SIZE= 90	PASS/FAIL CRITERION= 83
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.870	0.04315
0.875	0.05679
0.880	0.07403
0.885	0.09554
0.890	0.12201
0.895	0.15413
0.900	0.19249
0.905	0.23754
0.910	0.28959
0.915	0.34819
0.920	0.41330
0.925	0.48368
0.930	0.55453
0.935	0.63126
0.940	0.70466
0.945	0.77385
0.950	0.83606
0.955	0.88884
0.960	0.92378
0.965	0.96120
0.970	0.98122
0.975	0.99251
0.980	0.99775
0.985	0.99957
0.990	0.99996
0.995	1.00000
1.000	1.00000

SAMPLE SIZE= 90	PASS/FAIL CRITERION= 84
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.885	0.04523
0.890	0.06076
0.895	0.07923
0.900	0.10125
0.905	0.13306
0.910	0.16950
0.915	0.21126
0.920	0.26455
0.925	0.32441
0.930	0.39157
0.935	0.46539
0.940	0.54401
0.945	0.62503
0.950	0.70517
0.955	0.78049
0.960	0.84610
0.965	0.90300
0.970	0.94600
0.975	0.97436
0.980	0.99045
0.985	0.99750
0.990	0.99970
0.995	0.99999
1.000	1.00000

SAMPLE SIZE= 90	PASS/FAIL CRITERION= 85
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.900	0.04656
0.905	0.06280
0.910	0.08306
0.915	0.11076
0.920	0.14453
0.925	0.18527
0.930	0.23687
0.935	0.29689
0.940	0.36636
0.945	0.44454
0.950	0.52948
0.955	0.61808
0.960	0.70865
0.965	0.79217
0.970	0.86688
0.975	0.92469
0.980	0.96519
0.985	0.98834
0.990	0.99783
0.995	0.99990
1.000	1.00000

SAMPLE SIZE= 90 PASS/FAIL CRITERION= 86

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.915	0.04657
0.920	0.06467
0.925	0.08722
0.930	0.11736
0.935	0.15606
0.940	0.20656
0.945	0.26423
0.950	0.33560
0.955	0.41909
0.960	0.51262
0.965	0.61309
0.970	0.71513
0.975	0.81136
0.980	0.89125
0.985	0.95108
0.990	0.98786
0.995	0.99867
1.000	1.00000

SAMPLE SIZE= 90 PASS/FAIL CRITERION= 87

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.930	0.04439
0.935	0.06282
0.940	0.08798
0.945	0.12170
0.950	0.16643
0.955	0.22415
0.960	0.29697
0.965	0.38608
0.970	0.49181
0.975	0.61058
0.980	0.73117
0.985	0.84642
0.990	0.93006
0.995	0.9873
1.000	1.00000

SAMPLE SIZE= 90 PASS/FAIL CRITERION= 88

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.950	0.05573
0.955	0.08322
0.960	0.12063
0.965	0.17270
0.970	0.24390
0.975	0.33000
0.980	0.44043
0.985	0.60069
0.990	0.77867
0.995	0.92496
1.000	1.00000

SAMPLE SIZE= 90	PASS/FAIL CRITERION= 89	SAMPLE SIZE=100	PASS/FAIL CRITERION= 88	SAMPLE SIZE=100	PASS/FAIL CRITERION= 81
TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.965	0.04990	0.750	0.04953	0.750	0.06302
0.970	0.06469	0.755	0.12606	0.755	0.07859
0.975	0.10243	0.760	0.14537	0.760	0.09616
0.980	0.16231	0.765	0.17324	0.765	0.11719
0.985	0.25460	0.770	0.20468	0.770	0.14155
0.990	0.40673	0.775	0.23965	0.775	0.16963
0.995	0.63691	0.780	0.27835	0.780	0.20089
1.000	1.00000	0.785	0.31967	0.785	0.23693
		0.790	0.36423	0.790	0.27677
		0.795	0.41135	0.795	0.31689
		0.800	0.46026	0.800	0.36209
		0.805	0.51031	0.805	0.40969
		0.810	0.56096	0.810	0.45972
		0.815	0.61127	0.815	0.51087
		0.820	0.66046	0.820	0.56255
		0.825	0.70772	0.825	0.61302
		0.830	0.75232	0.830	0.66418
		0.835	0.79363	0.835	0.71224
		0.840	0.83111	0.840	0.75756
		0.845	0.86445	0.845	0.79936
		0.850	0.89346	0.850	0.83717
		0.855	0.91811	0	0.87060
		0.860	0.93855	0	0.89963
		0.865	0.95504	0	0.92372
		0.870	0.96806	0	0.94368
		0.875	0.97797	0.875	0.95964
		0.880	0.98529	0.880	0.97183
		0.885	0.99053	0.885	0.98103
		0.890	0.99413	0.890	0.98767
		0.895	0.99651	0.895	0.99232
		0.900	0.99802	0.900	0.99542
		0.905	0.99893	0.905	0.99746
		0.910	0.99946	0.910	0.99864
		0.915	0.99974	0.915	0.99929
		0.920	0.99988	0.920	0.99964
		0.925	0.99995	0.925	0.99983
		0.930	0.99998	0.930	0.99992
		0.935	0.99999	0.935	0.99996
		0.940	1.00000	0.940	0.99999
		0.945	1.00000	0.945	1.00000
		0.950	1.00000	0.950	1.00000
		0.955	1.00000	0.955	1.00000
		0.960	1.00000	0.960	1.00000
		0.965	1.00000	0.965	1.00000
		0.970	1.00000	0.970	1.00000
		0.975	1.00000	0.975	1.00000
		0.980	1.00000	0.980	1.00000
		0.985	1.00000	0.985	1.00000
		0.990	1.00000	0.990	1.00000
		0.995	1.00000	0.995	1.00000
		1.000	1.00000	1.000	1.00000

SAMPLE SIZE=100 TRUE VALUE OF P	PASS/FAIL CRITERION 02 PROBABILITY OF PASSING TEST	SAMPLE SIZE=100 TRUE VALUE OF P	PASS/FAIL CRITERION 03 PROBABILITY OF PASSING TEST	SAMPLE SIZE=100 TRUE VALUE OF P	PASS/FAIL CRITERION 04 PROBABILITY OF PASSING TEST
0.755	0.04776	0.765	0.04567	0.775	0.04225
0.760	0.06005	0.770	0.05761	0.780	0.05379
0.765	0.07651	0.775	0.07144	0.785	0.06703
0.770	0.09257	0.780	0.08876	0.790	0.08678
0.775	0.11356	0.785	0.10983	0.795	0.10606
0.780	0.13750	0.790	0.13316	0.800	0.12881
0.785	0.16587	0.795	0.16063	0.805	0.15599
0.790	0.19678	0.800	0.19236	0.810	0.18781
0.795	0.23211	0.805	0.22704	0.815	0.22316
0.800	0.27119	0.810	0.26727	0.820	0.26290
0.805	0.31353	0.815	0.31067	0.825	0.30677
0.810	0.35972	0.820	0.35731	0.830	0.35422
0.815	0.40638	0.825	0.40671	0.835	0.40406
0.820	0.45571	0.830	0.45963	0.840	0.45798
0.825	0.51144	0.835	0.51210	0.845	0.51270
0.830	0.56038	0.840	0.56021	0.850	0.56632
0.835	0.61002	0.845	0.62006	0.855	0.62352
0.840	0.66428	0.850	0.67244	0.860	0.67729
0.845	0.71710	0.855	0.72561	0.865	0.72069
0.850	0.76[illegible]28	0.860	0.76963	0.870	0.77641
0.855	0.80865	0.865	0.81267	0.875	0.81984
0.860	0.84577	0.870	0.85083	0.880	0.85886
0.865	0.87724	0.875	0.88424	0.885	0.89187
0.870	0.90578	0.880	0.91256	0.890	0.91977
0.875	0.92963	0.885	0.93564	0.895	0.94230
0.880	0.94895	0.890	0.95444	0.900	0.96011
0.885	0.96421	0.895	0.96677	0.905	0.97364
0.890	0.97562	0.900	0.97764	0.910	0.98352
0.895	0.98435	0.905	0.98690	0.915	0.99070
0.900	0.98999	0.910	0.99216	0.920	0.99615
0.905	0.99440	0.915	0.99562	0.925	0.99686
0.910	0.99654	0.920	0.99750	0.930	0.99863
0.915	0.99816	0.925	0.99879	0.935	0.99928
0.920	0.99907	0.930	0.99944	0.940	0.99976
0.925	0.99956	0.935	0.99976	0.945	0.99990
0.930	0.99982	0.940	0.99991	0.950	0.99996
0.935	0.99992	0.945	0.99997	0.955	0.99999
0.940	0.99997	0.950	0.99999	0.960	1.00000
0.945	0.99999	0.955	1.00000	0.965	1.00000
0.950	1.00000	0.960	1.00000	0.970	1.00000
0.955	1.00000	0.965	1.00000	0.975	1.00000
0.960	1.00000	0.970	1.00000	0.980	1.00000
0.965	1.00000	0.975	1.00000	0.985	1.00000
0.970	1.00000	0.980	1.00000	0.990	1.00000
0.975	1.00000	0.985	1.00000	0.995	1.00000
0.980	1.00000	0.990	1.00000	1.000	1.00000
0.985	1.00000	0.995	1.00000		
0.990	1.00000	1.000	1.00000		
0.995	1.00000				
1.000	1.00000				

SAMPLE SIZE=100 TRUE VALUE OF P	PASS/FAIL CRITERION= 85 PROBABILITY OF PASSING TEST	SAMPLE SIZE=100 TRUE VALUE OF P	PASS/FAIL CRITERION= 86 PROBABILITY OF PASSING TEST	SAMPLE SIZE=100 TRUE VALUE OF P	PASS/FAIL CRITERION= 87 PROBABILITY OF PASSING TEST
0.790	0.05042	0.800	0.04491	0.810	0.04326
0.795	0.06399	0.805	0.05996	0.815	0.05574
0.800	0.08834	0.810	0.07591	0.820	0.07121
0.805	0.10016	0.815	0.09517	0.825	0.08936
0.810	0.12350	0.820	0.11613	0.830	0.11235
0.815	0.15079	0.825	0.14516	0.835	0.13936
0.820	0.18127	0.830	0.17655	0.840	0.17032
0.825	0.21039	0.835	0.21253	0.845	0.20436
0.830	0.25027	0.840	0.25306	0.850	0.24730
0.835	0.30268	0.845	0.29816	0.855	0.29308
0.840	0.35101	0.850	0.34702	0.860	0.34340
0.845	0.40276	0.855	0.40061	0.865	0.39775
0.850	0.45722	0.860	0.45436	0.870	0.45637
0.855	0.51385	0.865	0.51436	0.875	0.51523
0.860	0.57044	0.870	0.57322	0.880	0.57612
0.865	0.62741	0.875	0.63176	0.885	0.63444
0.870	0.68266	0.880	0.68845	0.890	0.69534
0.875	0.73521	0.885	0.74250	0.895	0.75087
0.880	0.78430	0.890	0.79247	0.900	0.80182
0.885	0.82815	0.895	0.83717	0.905	0.84716
0.890	0.86695	0.900	0.87612	0.910	0.88616
0.895	0.90300	0.905	0.90893	0.915	0.91844
0.900	0.92763	0.910	0.93595	0.920	0.94412
0.905	0.94822	0.915	0.95630	0.925	0.96350
0.910	0.96553	0.920	0.97176	0.930	0.97759
0.915	0.97815	0.925	0.98273	0.935	0.98710
0.920	0.98670	0.930	0.99007	0.940	0.99311
0.925	0.99237	0.935	0.99469	0.945	0.99665
0.930	0.99591	0.940	0.99739	0.950	0.99856
0.935	0.99797	0.945	0.99883	0.955	0.99944
0.940	0.99908	0.950	0.99956	0.960	0.99982
0.945	0.99962	0.955	0.99984	0.965	0.99995
0.950	0.99986	0.960	0.99995	0.970	0.99999
0.955	0.99996	0.965	0.99999	0.975	1.00000
0.960	0.99999	0.970	1.00000	0.980	1.00000
0.965	1.00000	0.975	1.00000	0.985	1.00000
0.970	1.00000	0.980	1.00000	0.990	1.00000
0.975	1.00000	0.985	1.00000	0.995	1.00000
0.980	1.00000	0.990	1.00000	1.000	1.00000
0.985	1.00000	0.995	1.00000		
0.990	1.00000	1.000	1.00000		
0.995	1.00000				
1.000	1.00000				

SAMPLE SIZE=100	PASS/FAIL CRITERION= 88	SAMPLE SIZE=100	PASS/FAIL CRITERION= 89	SAMPLE SIZE=100	PASS/FAIL CRITERION= 90
TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST	TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.825	0.05131	0.835	0.04670	0.845	0.04191
0.830	0.06605	0.840	0.06071	0.850	0.05599
0.835	0.08616	0.845	0.07811	0.855	0.07167
0.840	0.10614	0.850	0.09946	0.860	0.09026
0.845	0.13244	0.855	0.12525	0.865	0.11760
0.850	0.16300	0.860	0.15640	0.870	0.14773
0.855	0.19956	0.865	0.19226	0.875	0.18370
0.860	0.24089	0.870	0.23372	0.880	0.22540
0.865	0.28740	0.875	0.28109	0.885	0.27372
0.870	0.33806	0.880	0.33360	0.890	0.32775
0.875	0.39473	0.885	0.39126	0.895	0.38726
0.880	0.45422	0.890	0.45287	0.900	0.45129
0.885	0.51622	0.895	0.51736	0.905	0.51661
0.890	0.57946	0.900	0.58316	0.910	0.58751
0.895	0.64222	0.905	0.64844	0.915	0.65401
0.900	0.70301	0.910	0.71180	0.920	0.72190
0.905	0.76026	0.915	0.77093	0.925	0.78127
0.910	0.81238	0.920	0.82433	0.930	0.83798
0.915	0.85828	0.925	0.87070	0.935	0.88465
0.920	0.89715	0.930	0.90922	0.940	0.92246
0.925	0.92870	0.935	0.93967	0.945	0.95136
0.930	0.95310	0.940	0.96230	0.950	0.97182
0.935	0.97096	0.945	0.97827	0.955	0.98423
0.940	0.98325	0.950	0.98853	0.960	0.99316
0.945	0.99111	0.955	0.99457	0.965	0.99729
0.950	0.99573	0.960	0.99776	0.970	0.99913
0.955	0.99818	0.965	0.99922	0.975	0.99978
0.960	0.99933	0.970	0.99979	0.980	0.99997
0.965	0.99980	0.975	0.99996	0.985	1.00000
0.970	0.99995	0.980	0.99999	0.990	1.00000
0.975	0.99999	0.985	1.00000	0.995	1.00000
0.980	1.00000	0.990	1.00000	1.000	1.00000
0.985	1.00000	0.995	1.00000		
0.990	1.00000	1.000	1.00000		
0.995	1.00000				
1.000	1.00000				

SAMPLE SIZE=100 PASS/FAIL CRITERION= 91

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.860	0.04921
0.865	0.06481
0.870	0.08443
0.875	0.10885
0.880	0.13859
0.885	0.17432
0.890	0.21651
0.895	0.26538
0.900	0.32067
0.905	0.38252
0.910	0.44948
0.915	0.52007
0.920	0.59263
0.925	0.66477
0.930	0.73397
0.935	0.79769
0.940	0.85371
0.945	0.90039
0.950	0.93691
0.955	0.96343
0.960	0.98101
0.965	0.99143
0.970	0.99678
0.975	0.99906
0.980	0.99981
0.985	0.99998
0.990	1.00000
0.995	1.00000
1.000	1.00000

SAMPLE SIZE=100 PASS/FAIL CRITERION= 92

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.870	0.04300
0.875	0.05759
0.880	0.07614
0.885	0.09949
0.890	0.12845
0.895	0.16377
0.900	0.20605
0.905	0.25571
0.910	0.31279
0.915	0.37691
0.920	0.44711
0.925	0.52160
0.930	0.59878
0.935	0.67532
0.940	0.74836
0.945	0.81482
0.950	0.87204
0.955	0.91816
0.960	0.95249
0.965	0.97563
0.970	0.98938
0.975	0.99630
0.980	0.99907
0.985	0.99986
0.990	0.99999
0.995	1.00000
1.000	1.00000

SAMPLE SIZE=100 PASS/FAIL CRITERION= 93

TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.880	0.04996
0.885	0.06717
0.895	0.08926
0.900	0.11716
0.905	0.15175
0.910	0.19398
0.915	0.24433
0.920	0.30326
0.925	0.37012
0.930	0.44428
0.935	0.52309
0.940	0.60436
0.945	0.68834
0.950	0.76601
0.955	0.83554
0.960	0.89361
0.965	0.93814
0.970	0.96877
0.975	0.98702
0.980	0.99594
0.985	0.99919
0.990	0.99993
0.995	1.00000
1.000	1.00000

SAMPLE SIZE=100	PASS/FAIL CRITERION= 94
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.895	0.04197
0.900	0.05750
0.905	0.0790[illegible]
0.910	0.10652
0.915	0.13009
0.920	0.17866
0.925	0.23041
0.930	0.29142
0.935	0.36164
0.940	0.44049
0.945	0.52654
0.950	0.61600
0.955	0.70495
0.960	0.78837
0.965	0.86118
0.970	0.91916
0.975	0.96008
0.980	0.98062
0.985	0.99591
0.990	0.99947
0.995	0.99999
1.000	1.00000

SAMPLE SIZE=100	PASS/FAIL CRITERION= 95
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.910	0.04730
0.915	0.06506
0.920	0.09034
0.925	0.12229
0.930	0.16316
0.935	0.21432
0.940	0.27678
0.945	0.36009
0.950	0.43590
0.955	0.52993
0.960	0.62806
0.965	0.72716
0.970	0.81706
0.975	0.89373
0.980	0.94617
0.985	0.98231
0.990	0.99657
0.995	0.99904
1.000	1.00000

SAMPLE SIZE=100	PASS/FAIL CRITERION= 96
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.925	0.05258
0.930	0.07641
0.935	0.10391
0.940	0.14382
0.945	0.19376
0.950	0.25704
0.955	0.33646
0.960	0.42948
0.965	0.53478
0.970	0.64725
0.975	0.75808
0.980	0.85896
0.985	0.92576
0.990	0.98163
0.995	0.99833
1.000	1.00000

SAMPLE SIZE=100	PASS/FAIL CRITERION 97
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.940	0.05661
0.945	0.08230
0.950	0.11026
0.955	0.16716
0.960	0.23216
0.965	0.31591
0.970	0.41978
0.975	0.54219
0.980	0.67669
0.985	0.80981
0.990	0.92063
0.995	0.98598
1.000	1.00000

SAMPLE SIZE=100	PASS/FAIL CRITERION 98
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.955	0.05714
0.960	0.08716
0.965	0.13123
0.970	0.19462
0.975	0.28341
0.980	0.40327
0.985	0.55656
0.990	0.73576
0.995	0.91018
1.000	1.00000

SAMPLE SIZE=200	PASS/FAIL CRITERION 99
TRUE VALUE OF P	PROBABILITY OF PASSING TEST
0.970	0.04798
0.975	0.07952
0.980	0.13062
0.985	0.22061
0.990	0.36603
0.995	0.60577
1.000	1.00000

APPENDIX B - FIR(L) DEMONSTRATION TEST PLAN EXAMPLES

Tables B-1 through B-6 contain examples of the statistical demonstration technique described for FIR(L) in Section 5.2.2. A description on how the test plans were developed, and how to use the demonstration test plans is contained in Section 5.2.2.

TABLE B-1. EXAMPLE 1 OF A DEMONSTRATION TEST PLAN FOR FIR(L)

Design Goal Values:

FIR(L1) = 0.9000
FIR(L2) = 0.9500
FIR(L3) = 1.0000

Minimum Acceptable Values:

FIR(L1) = 0.8500
FIR(L2) = 0.9300
FIR(L3) = 1.000

Prespecified Consumer Risk (Beta): 0.1000

Coefficient in Test Statistic:

	0.05716	-0.47000	-0.33647
Sample Size	**Exact Beta**	**Exact Alpha**	**Pass/Fail Value**
50	0.0881	0.6253	0.8943
60	0.1016	0.5495	0.9139
70	0.0956	0.5250	0.9219
80	0.0904	0.5019	0.9206
90	0.1011	0.4409	0.9118
100	0.0940	0.4259	0.8986
110	0.1011	0.3790	0.8760
120	0.0938	0.3679	0.8508
130	0.0997	0.3282	0.8214
140	0.0924	0.3200	0.7884
150	0.0971	0.2866	0.7521

TABLE B-2. EXAMPLE 2 OF A DEMONSTRATION TEST PLAN FOR FIR(L)

Design Goal Values:

FIR(L1) = 0.9000
FIR(L2) = 0.9500
FIR(L3) = 1.0000

Minimum Acceptable Values:

FIR(L1) = 0.8500
FIR(L2) = 0.9000
FIR(L3) = 1.000

Preapecified Consumer Risk (Beta): 0.2000

Coefficients in Test Statistic:

	0.05716	-0.47000	-0.33647

Sample Size	Exact Beta	Exact Alpha	Pass/Fail Value
50	0.1959	0.4161	0.3693
60	0.2039	0.3633	0.3388
70	0.2157	0.3116	0.3007
80	0.1968	0.3041	0.2506
90	0.2034	0.2664	0.2074
100	0.2091	0.2337	0.1541
110	0.2136	0.2060	0.0973
120	0.1961	0.2066	0.0374
130	0.1900	0.1803	-0.0251
140	0.2030	0.1599	-0.0901
150	0.2057	0.1422	-0.1572

TABLE B-3. EXAMPLE 3 OF A DEMONSTRATION TEST PLAN FOR FIR(L)

Design Goal Values:

F(R(L1) = 0.9500
FIR(L2) = 0.9900
FIR(L3) = 1.000

Minimum Acceptable Values:

FIR(L1) = 0.9000
FIR(L2) = 0.9400
FIR(L3) = 1.0000

Prespecified Consumer Risk (Beta): 0.1000

Coefficients in Test Statistic:

0.05407	-0.28768	-1.09861

Sample Size	Exact Beta	Exact Alpha	Pass/Fail Value
50	0.0972	0.4361	1.0859
60	0.0949	0.3777	1.0392
70	0.0899	0.3377	0.9731
80	0.0938	0.2757	0.8917
90	0.0898	0.2432	0.7978
100	0.0912	0.2025	0.6933
110	0.0956	0.1630	0.5799
120	0.0976	0.1340	0.4587
130	0.0947	0.1161	0.3308
140	0.0932	0.0907	0.1968
150	0.0942	0.0812	0.0574

TABLE B-4. EXAMPLE 4 OF A DEMONSTRATION TEST PLAN FOR FIR(L)

Design Goal Values:

FIR(L1) = 0.9600
FIR(L2) = 0.9800
FIR(L3) = 1.000

Minimum Acceptable Values:

FIR(L1) = 0.9000
FIR(L2) = 0.9400
FIR(L3) = 1.0000

Prespecified Consumer Risk (Beta): 0.2000

Coefficients in Test Statistic.

	0.05407	-0.28768	-1.09861
Sample Size	Exact Beta	Exact Alpha	Pass/Fail Value
50	0.1966	0.2159	0.2157
60	0.2110	0.1796	0.0859
70	0.2101	0.1356	-0.0666
80	0.2184	0.1087	-0.2091
90	0.2028	0.0970	-0.3698
100	0.1959	0.0814	-0.5374
110	0.1961	0.0650	-0.7109
120	0.2034	0.0488	-1.8805
130	0.2024	0.0392	-1.7025
140	0.2035	0.0309	-1.2504
150	0.2046	0.0243	-1.4199

TABLE B-5. EXAMPLE 5 OF A DEMONSTRATION TEST PLAN FOR FIR(L)

Design Goal Values:

FIR(L1) = 0.8000
FIR(L2) = 0.9000
FIR(L3) = 1.0000

Minimum Acceptable Values:

FIR(L1) = 0.7000
FIR(L2) = 0.8750
FIR(L3) = 1.0000

Prespecified Consumer Risk (Beta): 0.1000

Coefficients in Test Statistic:

	0.13353	-0.55962	-0.22314

Sample Size	Exact Beta	Exact Alpha	Pass/Fail Value
50	0.0889	0.3557	0.8226
60	0.0875	0.2970	0.7319
70	0.0918	0.2373	0.6226
80	0.1068	0.1682	0.4984
90	0.1016	0.1434	0.3821
100	0.0958	0.1229	0.2156
110	0.0910	0.1051	0.0806
120	0.1048	0.0726	-0.1020
130	0.0982	0.0620	-0.2712
140	0.0931	0.0538	-0.4462
150	0.1016	0.0387	-0.6264

TABLE B-6. EXAMPLE 6 OF A DEMONSTRATION TEST PLAN FOR FIR(L)

Design Goal Values:

FIR(L1) = 0.8000
FIR(L2) = 0.9000
FIR(L3) = 1.0000

Minimum Acceptable Values:

FIR(L1) = 0.7000
FIR(L2) = 0.8750
FIR(L3) = 1.0000

Prespecified Consumer Risk (Beta): 0.2000

Coefficients in Test Statistic:

0.13353	-0.55962	-0.22314

Sample Size	Exact Beta	Exact Alpha	Pass/Fail Value
50	0.2315	0.1615	-0.0188
60	0.2050	0.1356	-0.1897
70	0.1892	0.1156	-0.3729
80	0.2154	0.0745	-0.5658
90	0.1904	0.0641	-0.7667
100	0.2045	0.0478	-0.9742
110	0.2049	0.0362	-1.1873
120	0.1914	0.0312	-1.4054
130	0.2076	0.0207	-1.6278
140	0.1934	0.0181	-1.8549
150	0.2085	0.0120	-2.0837

APPENDIX C – INDUSTRY SURVEY DATA

The tables listed on the following pages summarize the data received through the industry survey (see Section 2.4). The tables are organized by FOMs in the following order:

Table C-1. %FD – percent of faults detected by BIT/ETE (analogous to FFD)

Table C-2. FAR/FSI – false alarm rate and/or false status indications (analogous to FFA and FFSI)

Table C-3. FIAL – fault isolation ambiguity level (analogous to FIR(L))

Table C-4. %FI – percent of fault isolation with BIT/ETE (analogous to FFI)

Table C-5. SYS MTBF – system MTBF

Table C-6. MPSL – maintenance personnel skill level

Table C-7. B/E Rel – BIT/ETE reliability (analogous to $MTBF_{B/E}$)

Table C-8. B/E WT & VOL – BIT/ETE weight/volume (analogous to physical amount/size FOMs)

The abbreviations and codes used in the tables are:

1) COMPANY – denotes the company that the survey was received from. Companies were denoted by numerals only.

2) EQUIP – denotes the equipment type the FOMs have been experienced on

- AV – avionic equipment
- MI – missiles
- GRD – ground electronic equipment
- SHP – shipboard equipment
- OTH – other

3) EXPERIENCE – these columns denote the surveyed company's experience with the FOM. A check mark denotes that they have had experience with the FOM in one of the following areas:

- SPEC – thru specifications
- ANA – thru analysis
- DEMO – thru demonstration

4) SUITABILITY – these columns denote the scores given for each FOMs suitability factor. The suitability factors are:

- TRANS – translatability
- TRACK – trackability
- DEMO – demonstrability
- AMBIG – ambiguity
- GEN – generality
- COST – cost
- AVE – the average score

TABLE C-1. FOM = % FD

COMPANY	EQUIP	EXPERIENCE			SUITABILITY						
		SPEC	ANAL	DEMO	TRANS	TRACK	DEMO	AMMO	GEN	COST	AVE
1	AV	✓	✓		10	10	10	10	7	8	9
	MI	✓	✓		10	10	10	10	7	8	9
	GRD	-	-	-							
	SHP	-			-						
2	GRD	✓	✓	-	10	8	4	9	8	8	8
3	AV	✓	✓	-	3	5	5	5	5	3	5
4	AV	✓	-	✓	7	8	10	8		5	8
	GRD	✓		✓	7	6	10	8		5	8
	OTH	✓		✓	7	8	10	6		6	5
5	AV	✓	✓	✓	8	9	9	8			9
6	AV	✓	✓	-							
7	AV	✓	✓	✓	9	7	9	7	10	9	9
8	SHP	✓	✓	✓	7	9	10	-	-	-	9
9	AV	✓	✓		8	2	3	9	9	4	6
	GRD	✓	✓	-	9	2	3	9	9	4	6
	SHP	✓	✓	-	9	2	3	9	9	4	6
	OTH	-	-								
10	AV	✓	✓	✓	8	6	9	3	8		6
	GRD	✓	✓	✓	8	6	9	3	5		6
	SHP	✓	✓	✓	8	6	9	3	8		6
11	GRD	✓	-	-							
12	SHP	✓	✓	-	5	6	4	5	8	6	7
13	AV	✓	✓	✓	6	3	3	6	3	3	4
14	AV	✓	✓		6	4	-	4			5
	GRD	-									
15	GRD	-	-	-							
	OTH										
16	AV	-	✓	✓	-	-					
	GRD	✓	-	✓	-						
	SHP	-									
17	AV	✓	✓	✓	2	6	7	2	7	9	6
	MI	✓	✓	✓	2	6	7	2	7	9	5
	GRD	✓	✓	✓	2	6	7	2	7	9	5
	SHP	✓	✓	✓	2	6	7	3	7	9	6
18	AV	✓	✓		6	9	8	10	1	10	4
19	SHP	✓	✓		8	9	8	4	6	6	7
20	AV	✓	✓	✓	8	8	8	6	9	4	7
21	AV	-			-	-	-	-			
	GRD	-	-	-	-	-	-	-			

TABLE C-1. FOM = % FD (Continued)

COMPANY	EQUIP	EXPERIENCE			SUITABILITY						
		SPEC	ANAL	DEMO	TRANS	TRACK	DEMO	AMBIG	GEN	COST	AVE
32	MS	√	√	-	-	-	-	-	-	-	-
	OTH	√	√	-	-	-	-	-	-	-	-
33	AV	√	√	√	8	8	5	6	8	8	7
	SHIP	√	√	√	9	6	5	5	9	9	7
34	AV	√	√	-	5	6	1	10	10	-	4
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
35	OTH	-	-	-	-	-	-	-	-	-	-
36	AV	√	√	√	8	6	9	9	6	1	7
37	GRD	-	-	√	-	-	-	-	-	-	-
38	AV	√	√	-	8	9	1	5	10	-	6

TABLE C-2. FOM: FAR/FPR

COMPANY	EQUIP	EXPERIENCE			SUITABILITY						
		SPEC	ANAL	DEMO	TRANS	TRACK	DEMO	AMBIG	GEN	COST	AVE
1	AV	✓	✓	-	10	10	10	10	7	8	9
	MI	✓	✓	-	10	10	10	10	7	8	9
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
2	GRD	✓	✓	-	5	4	2	8	6	7	5
3	AV	✓	✓	-	6	6	6	6	6	6	6
4	AV	-	-	-	3	3	10	5	-	8	6
	GRD	-	-	-	3	3	10	5	-	8	6
	OTH	-	-	-	3	3	10	5	-	8	6
5	AV	✓	✓	-	-	2	2	3	-	-	3
6	AV	-	-	-	-	-	-	-	-	-	-
7	AV	-	✓	✓	6	5	6	3	5	5	5
8	SHIP	-	-	-	5	5	5	-	-	-	5
9	AV	-	-	-	-	-	-	-	-	-	-
	GRD	✓	-	-	2	2	5	9	2	2	4
	SHIP	-	-	-	-	-	-	-	-	-	-
	OTH	-	-	-	-	-	-	-	-	-	-
10	AV	-	-	-	2	2	2	3	2	-	2
	GRD	-	-	-	2	2	2	3	2	-	2
	SHIP	-	-	-	2	2	2	3	2	-	2
11	GRD	-	-	-	-	-	-	-	-	-	-
12	SHIP	✓	✓	-	4	3	3	3	8	10	5
13	AV	-	-	-	-	-	-	-	-	-	-
14	AV	✓	✓	-	5	4	-	6	-	-	5
	GRD	-	-	-	-	-	-	-	-	-	-
15	GRD	-	-	-	-	-	-	-	-	-	-
	OTH	-	-	-	-	-	-	-	-	-	-
16	AV	✓	✓	-	-	-	-	-	-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
17	AV	✓	✓	-	2	2	3	2	7	9	4
	MI	-	-	-	-	-	-	-	-	-	-
	GRD	✓	✓	✓	2	2	3	2	7	9	4
	SHIP	✓	✓	✓	2	2	3	2	7	9	4
18	AV	-	-	✓	3	0	0	4	1	10	3
19	SHIP	✓	-	✓	2	2	4	5	2	7	4
20	AV		-	-	9	8	8	6	8	3	7
21	AV	-	-	-	-	-	-	-	-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-

TABLE C-2. FOM: PAR/FSI (Continued)

COMPANY	EQUIP	EXPERIENCE SPEC	EXPERIENCE ANAL	EXPERIENCE DEMO	SUITABILITY TRANS	SUITABILITY TRACK	SUITABILITY DEMO	SUITABILITY AMBG	SUITABILITY GEN	SUITABILITY COST	SUITABILITY AVE
22	MI	-	-	-	-	-	-	-	-	-	-
	OTH	✓	-	-	-	-	-	-	-	-	-
23	AV	✓	✓	✓	6	3	3	6	5	6	4
	SIMP	✓	✓	✓	5	3	3	6	5	5	4
24	AV	-	-	-	-	-	-	-	-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-
	SIMP	-	-	-	-	-	-	-	-	-	
25	OTH	-	-	-	-	-	-	-	-	-	
26	AV	-	-	-	-	-	-	-	-	-	-
27	GRD	-	-	✓	-	-	-	-	-	-	-
28	AV	-	-	-	-	-	-	-	-	-	

TABLE C-3. FOM: FIAL

COMPANY	EQUIP	EXPERIENCE SPEC	EXPERIENCE ANAL	EXPERIENCE DEMO	SUITABILITY TRANS	SUITABILITY TRACK	SUITABILITY DEMO	SUITABILITY AMBIG	SUITABILITY GEN	SUITABILITY COST	SUITABILITY AVE
1	AV	-	-	-	1	1	1	1	1	1	1
	MI	-	-	-	1	1	1	1	1	1	1
	GRD	-	-	-	1	1	1	1	1	1	1
	SHIP	-	-	-	1	1	1	1	1	1	1
2	GRD	✓	✓	-	7	6	3	8	7	5	6
3	AV	✓	✓	-	3	5	5	5	8	5	5
4	AV	-	-	-	5	5	10	5	-	10	7
	GRD	-	-	-	5	5	10	5	-	10	7
	OTM	-	-	-	5	5	10	5	-	10	7
5	AV	✓	✓	-	9	9	9	9	-	-	9
6	AV	-	-	-	-	-	-	-	-	-	-
7	AV	-	✓	-	5	4	7	4	6	3	5
8	SHIP	-	-	-	7	7	7	-	-	-	7
9	AV	✓	✓	-	5	2	8	9	9	4	6
	GRD	✓	✓	-	5	2	8	9	9	4	6
	SHIP	-	-	-	-	-	-	-	-	-	-
	OTM	-	-	-	-	-	-	-	-	-	-
10	AV	-	-	-	5	5	8	3	6	-	5
	GRD	-	-	-	5	5	8	3	5	-	5
	SHIP	-	-	-	5	5	8	3	5	-	5
11	GRD	-	-	-	-	-	-	-	-	-	
12	SHIP	✓	✓	-	9	8	7	7	9	9	5
13	AV	-	-	-	5	3	3	5	3	3	4
14	AV	✓	✓	-	5	3	-	6	-	-	5
	GRD	-	-	-	5	3	-	6	-	-	5
15	GRD	-	-	-	-	-		-	-	-	-
	OTM	-	-	-	-	-	-	-	-	-	-
16	AV	✓	✓	-	-	-	-	-	-	-	
	GRD	-	-	-	-	-	-	-	-	-	
	SHIP	-	-	-	-	-	-	-	-	-	
17	AV	✓	✓	-	2	5	7	2	9	9	6
	MI	-	-	-	-	-	-	-	-		
	GRD	✓	✓	-	2	5	7	2	9	9	6
	SHIP	✓	✓	-	2	5	7	2	9	9	6
18	AV	-	-	✓	5	1	5	8	1	9	5
19	SHIP	✓	-	✓	6	9	7	3	4	6	5
20	AV	-	-	-	7	8	4	2	5	3	4
21	AV	-	-	-	-	-	-	-	-		
	GRD	-	-	-	-	-	-	-	-		

TABLE C-3. FOM: FIAL (Continued)

COMPANY	EQUIP	EXPERIENCE			SUITABILITY						
		SPEC	ANAL	DEMO	TRANS	TRACK	DEMO	AMMU	GEN	COST	AVE
22	MR	✓	✓	✓	-	-	-	-	-	-	-
	OTR	✓	✓	✓	-	-	-	-	-	-	-
23	AV	✓	✓	✓	5	3	3	5	5	3	4
	SHLP	✓	✓	✓	6	3	3	6	6	3	4
24	AV	✓	✓	-	10	10	10	10	10	-	8
	GRD	-	-	-	-	-	-	-	-	-	-
	SHLP	-	-	-	-	-	-	-	-	-	-
25	OTM	-	-	-	-	-	-	-	-	-	-
26	AV	-	-	-	-	-	-	-	-	-	-
27	GRD	-	-	✓	-	-	-	-	-	-	-
28	AV	-	-	-	-	-	-	-	-	-	-

TABLE C-4. FOM: % FI

COMPANY	EQUIP	EXPERIENCE: SPEC	EXPERIENCE: ANAL	EXPERIENCE: DEMO	SUITABILITY: TRANS	SUITABILITY: TRACK	SUITABILITY: DEMO	SUITABILITY: AMB	SUITABILITY: GEN	SUITABILITY: COST	SUITABILITY: AVE
1	AV	✓	✓	-	9	9	8	9	7	6	8
	MI	✓	✓	-	9	9	8	9	7	6	8
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
2	GRD	✓	✓	-	9	4	4	8	8	9	7
3	AV	✓	✓	-	3	6	5	5	8	5	5
4	AV	✓	✓	✓	8	8	10	8	-	8	8
	GRD	✓	✓	✓	8	8	10	6	-	8	8
	OTH	✓	✓	✓	8	6	10	6	-	5	8
5	AV	✓	✓	✓	9	9	9	9	-	-	9
6	AV	✓	✓	-	-	-	-	-	-	-	-
7	AV	-	✓	-	10	9	10	8	10	9	9
8	SHIP	✓	✓	✓	7	7	7	-	-	-	7
9	AV	✓	✓	-	9	2	5	9	9	4	6
	GRD	✓	✓	-	3	2	5	9	9	4	6
	SHIP	✓	✓	-	9	2	5	9	9	4	6
	OTH	-	-	-	-	-	-	-	-	-	-
10	AV	✓	✓	✓	8	6	9	3	6	-	6
	GRD	✓	✓	✓	8	6	9	3	5	-	6
	SHIP	✓	✓	✓	9	6	9	3	5	-	6
11	GRD	-	-	-	-	-	-	-	-	-	-
12	SHIP	✓	✓	-	8	6	6	6	9	9	7
13	AV	✓	-	-	5	3	3	5	3	3	4
14	AV	✓	✓	✓	5	3	-	4	-	-	4
	GRD	-	-	-	-	-	-	-	-	-	-
15	GRD	-	-	-	-	-	-	-	-	-	-
	OTH	-	-	-	-	-	-	-	-	-	-
16	AV	✓	✓	-	-	-	-	-	-	-	-
	GRD	✓	-	✓	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
17	AV	✓	✓	✓	2	5	7	2	7	9	6
	MI	-	-	-	-	-	-	-	-	-	-
	GRD	✓	✓	✓	2	5	7	2	7	9	6
	SHIP	✓	✓	✓	3	5	7	8	7	9	5
18	AV	✓	✓	✓	4	2	2	9	1	6	4
19	SHIP	-	-	-	2	2	4	2	6	6	4
20	AV	✓	✓	✓	9	4	5	4	3	5	6
21	AV	-	-	-	-	-	-	-	-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-

TABLE C-4. FOM: % Fl (Continued)

COMPANY	EQUIP	EXPERIENCE			SUITABILITY						
		SPEC	ANAL	DEMO	TRANS	TRACK	DEMO	AMBIG	GEN	COST	AVE
22	MK	-	✓	✓	-	-	-	-	-	-	-
	OTM	-	✓	✓	-	-	-	-	-	-	-
23	AV	✓	✓	✓	8	5	6	8	3	3	5
	SHIP	✓	✓	✓	8	5	5	8	3	3	5
24	AV	✓	✓	-	6	5	6	6	5	-	4
	GnD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
25	OTM	-	-	-	-	-	-	-	-	-	-
26	AV	✓	✓	✓	8	6	9	8	4	1	6
27	GRD	-	-	✓	-	-	-	-	-	-	-
28	AV	✓	✓	-	9	9	1	5	10	-	6

TABLE C-5. FOM: SYS MTBF

COMPANY	EQUIP	EXPERIENCE SPEC	EXPERIENCE ANAL	EXPERIENCE DEMO	SUITABILITY TRANS	SUITABILITY TRACK	SUITABILITY DEMO	SUITABILITY AMBIG	SUITABILITY GEN	SUITABILITY COST	SUITABILITY AVE
1	AV	✓	✓	✓	10	10	10	10	9	9	10
	MI	✓	✓	✓	10	10	10	10	9	9	10
	GRD	✓	✓	✓	10	10	10	10	9	9	10
	SMP	✓	✓	✓	10	10	10	10	9	9	10
2	GRD	✓	✓	✓	10	9	8	9	9	9	9
3	AV	✓	✓	✓	10	10	10	10	10	10	10
4	AV	✓	✓	✓	8	6	10	5	-	1	6
	GRD	✓	✓	✓	8	6	10	5	-	1	6
	OTM	✓	✓	✓	8	6	10	5	-	1	6
5	AV	✓	✓	✓	9	9	9	9	-	-	9
6	AV	✓	✓	-	-	-	-	-	-	-	-
7	AV	✓	✓	✓	9	8	9	7	10	4	8
8	SMP	✓	✓	✓	10	10	10	-	-	-	10
9	AV	✓	✓	✓	5	10	9	9	9	8	8
	GRD	✓	✓	✓	5	10	9	9	9	8	9
	SMP	✓	✓	✓	5	10	9	9	9	8	8
	OTM	✓	✓	✓	5	10	9	9	9	8	8
10	AV	✓	✓	✓	8	6	8	5	10	-	9
	GRD	✓	✓	✓	8	6	8	8	10	-	8
	SMP	✓	✓	✓	8	6	8	8	10	-	8
11	GRD	✓	✓	-	-	-	-	-	-	-	-
12	SMP	✓	✓	-	8	7	7	8	9	8	8
13	AV	✓	✓	✓	9	7	6	7	7	5	7
14	AV	✓	✓	✓	8	-	-	8	-	-	8
	GRD	✓	✓	✓	8	-	-	8	-	-	8
15	GRD	✓	✓	✓	10	-	10	10	10	-	10
	OTM	✓	✓	✓	10	-	10	10	10	-	10
16	AV	✓	✓	✓	-	-	-	-		-	
	GRD	✓	✓	✓	-	-	-	-	-	-	-
	SMP	✓	✓	✓	-	-	-	-	-	-	-
17	AV	✓	✓	✓	2	7	8	7	9	6	7
	MI	✓	✓	✓	2	7	8	7	9	6	7
	GRD	✓	✓	✓	2	7	8	7	9	6	7
	SMP	✓	✓	✓	2	7	8	7	9	6	7
18	AV	✓	✓	✓	9	10	9	8	1	6	7
19	SMP	✓	✓	-	10	10	10	10	10	3	9
20	AV	✓	✓	✓	10	10	10	10	10	3	9
21	AV	✓	✓	✓	-	-	-	-	-	-	
	GRD	✓	✓	✓	-	-	-	-			

TABLE C-6. FOM: SYS MTBF (Continued)

COMPANY	EQUIP	EXPERIENCE			SUITABILITY						
		SPEC	ANAL	DEMO	TRANS	TRACK	DEMO	AMMO	GEN	COST	AVE
22	MS	✓	✓	-	-	-	-	-	-	-	-
	OTH	✓	✓	-	-	-	-	-	-	-	-
23	AV	✓	✓	✓	10	8	8	10	10	8	9
	SHIP	✓	✓	✓	10	8	8	10	10	8	9
24	AV	✓	✓	✓	10	10	10	10	10	-	8
	GRD	✓	✓	✓	10	10	10	10	10	-	8
	SHIP	✓	✓	✓	10	10	10	10	10	-	8
25	OTH	✓	✓	-	9	9	7	5	9	6	7
26	AV	✓	✓	✓	10	9	9	9	10	5	9
27	GRD	-	-	-	-	-	-	-	-	-	-
28	AV	-	✓	-	-	-	-	-	-	-	-

TABLE C-6. FOM: MPSL

COMPANY	EQUIP	EXPERIENCE			SUITABILITY						
		SPEC	ANAL	DEMO	TRANS	TRACK	DEMO	AMMO	GEN	COST	AVE
1	AV	✓	✓	-	10	10	10	10	.	7	9
	MI	✓	✓	-	10	10	10	10	7	7	9
	GRD	-	-	-	-	-	.	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
2	GRD	✓	✓	-	5	6	3	7	8	7	6
3	AV	✓	✓		10	10	10	10	10	10	10
4	AV	✓	✓	✓	10	10	10	9	-	1	6
	GRD	✓	✓	✓	10	10	10	9	-	1	6
	OTH	✓	✓	✓	10	10	10	9	-	1	8
5	AV	✓	✓	✓	9	9	9	9	-	-	9
6	AV	✓	✓	-	-	-	-	-	-	-	.
7	AV	-	✓	-	3	3	5	3	5	0	4
8	SHIP	-	-	-	4	3	4	-	.	-	4
9	AV	✓	✓	✓	9	9	9	2	9	9	8
	GRD	✓	✓	✓	9	9	9	2	9	9	8
	SHIP	✓	✓	✓	9	9	9	2	9	9	8
	OTH	✓	✓	✓	9	9	9	2	9	9	8
10	AV	✓	✓	-	1	1	1	1	1	1	1
	GRD	✓	✓	-	1	1	1	1	1	1	1
	SHIP	✓	✓	-	1	1	1	1	1	1	1
11	GRD	-	✓	-	-	-	-	-	-	-	-
12	SHIP	✓	✓	-	4	3	3	3	7	8	5
13	AV	✓	-	✓	9	7	5	5	5	5	6
14	AV	✓	-	-	10	-	-	10	-	-	10
	GRD	✓	-	-	10	-	-	10	-	-	10
15	GRD	-	-	-	-	-	-	-	-	-	-
	OTH	-	-	-	-	-	-	-	-	-	-
16	AV	✓	✓	✓	-	-	-	-	-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	✓	✓	✓	-	-	-	-	-	-	-
17	AV	-	-	-	2	7	8	7	9	6	7
	MI	-	-	-	2	7	8	7	9	6	7
	GRD	-	-	-	2	7	8	7	9	6	7
	SHIP	-	-	-	2	7	8	7	9	6	7
18	AV	✓	✓	✓	10	9	10	3	1	1	6
19	SHIP	✓	-	-	4	3	4	5	2	8	6
20	AV	✓	-	-	9	5	6	5	5	3	6
21	AV	✓	✓	✓	-	-	-	-	-	-	-
	GND	-	-	-	-	-	-	-	-	-	-

TABLE C-6. FOM: MPSL (Continued)

COMPANY	EQUIP	EXPERIENCE			SUITABILITY						
		SPEC	ANAL	DEMO	TRANS	TRACK	DEMO	AMMO	GEN	COST	AVE
22	MI	-	-	-	-	-	-	-	-	-	-
	OTM	-	-	-	-	-	-	-	-	-	-
23	AV	✓	-	-	3	3	2	3	5	5	4
	SHIP	✓	-	-	3	3	3	3	5	5	4
24	AV	✓	✓	✓	2	3	8	3	10	-	5
	GRD	✓	✓	✓	3	3	8	3	10	-	5
	SHIP	✓	✓	✓	3	3	8	3	10	-	5
25	OTM	✓	✓	-	9	8	5	8	7	8	7
26	AV	✓	✓	✓	8	7	9	9	6	1	7
27	GRD	✓	✓	-	-	-	-	-		-	-
28	AV	-	✓	-	-	-	-	-	-	-	-

TABLE C-7. FOM: B/E REL

COMPANY	EQUIP	EXPERIENCE SPEC	EXPERIENCE ANAL	EXPERIENCE DEMO	SUITABILITY TRANS	SUITABILITY TRACK	SUITABILITY DEMO	SUITABILITY AMBIG	SUITABILITY GEN	SUITABILITY COST	SUITABILITY AVG
1	AV	-	-	-	1	1	1	1	1	1	1
	MI	-	-	-	1	1	1	1	1	1	1
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
2	GRD	✓	✓	✓	9	9	8	8	8	8	8
3	AV	✓	✓	-	10	10	10	10	10	10	10
4	AV	✓	✓	✓	8	10	10	8	-	1	7
	GRD	✓	✓	✓	8	10	10	8	-	1	7
	OTH	✓	✓	✓	8	10	10	8	-	1	7
5	AV	✓	✓	-	9	9	9	9	-	-	9
6	AV	-	-	-	-	-	-	-	-	-	-
7	AV	-	✓	-	4	3	2	2	7	3	4
8	SHIP	-	-	-	9	9	9	-	-	-	9
9	AV	-	-	-	-	-	-	-	-		-
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
	OTH	✓	-	-	5	10	8	9	9	7	8
10	AV	-	-	-	10	10	1	10	10	-	8
	GRD	-	-	-	10	10	1	10	10	-	8
	SHIP	-	-	-	10	10	1	10	10	-	8
11	GRD	-	-	-	-	-	-	-	-	-	-
12	SHIP	-	-	-	6	5	4	4	8	5	5
13	AV	-	-	-	8	7	5	7	7	6	7
14	AV	✓	✓	-	9	9	-	9	-	-	9
	GRD	-	-	-	-	-	-	-	-	-	-
15	GRD	-	-	-	-	-	-	-	-	-	-
	OTH	-	-	-	-	-	-	-	-	-	-
16	AV	-	✓	-	-	-	-		-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
17	AV	-	✓	-	2	3	5	2	7	8	5
	MI	-	-	-	-	-	-	-	-	-	
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
18	AV	-	✓	-	8	7	1	1	1	7	4
19	SHIP	-	-	-	10	10	9	10	10	3	8
20	AV	✓	✓	-	8	8	8	8	8	3	7
21	AV	✓	✓	✓	-	-	-	-		-	
	GRD	-	-	-	-	-	-	-	-		

TABLE C-7. FOM: B/E REL (Continued)

COMPANY	EQUIP	EXPERIENCE SPEC	ANAL	DEMO	SUITABILITY TRANS	TRACK	DEMO	AMBIG	GEN	COST	AVE
22	MI	-	-	-	-	-	-	-	-	-	-
	OTH	-	-	-	-	-	-	-	-	-	-
23	AV	✓	✓	✓	6	3	3	5	8	5	4
	SHIP	✓	✓	✓	5	3	3	5	6	8	4
24	AV	-	-	-	-	-	-	-	-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
25	OTH	✓	✓	-	9	9	8	7	7	7	8
26	AV	✓	✓	✓	10	8	9	9	10	5	9
27	GRD	✓	✓	-	-	-	-	-	-	-	-
28	AV	-	✓	-	-	-	-	-	-	-	-

TABLE C-8. FOM: B/E WT & VOL (Continued)

COMPANY	EQUIP	EXPERIENCE			SUITABILITY						
		SPEC	ANAL	DEMO	TRANS	TRACK	DEMO	AMMO	GEN	COST	AVE
1	AV	-	-	-	1	1	1	1	1	1	1
	MI	-	-	-	-	-	-	-	-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
2	GRD	-	-	-	6	7	8	8	6	[illegible]	7
3	AV	-	-	-	[illegible]	0	0	0	0	0	0
4	AV	✓	✓	✓	10	10	10	10	-	1	8
	GRD	✓	✓	✓	10	10	10	10	-	1	8
	OTH	✓	✓	✓	10	10	10	10	-	1	8
5	AV	-	-	-	9	9	9	9	-	-	9
6	AV	✓	✓	✓	-	-	-	-	-	-	-
7	AV	-	-	-	2	3	8	7	3	2	4
8	SHIP	-	-	-	5	10	10	-	-	-	8
9	AV	-	-	-	-	-	-	-	-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
	OTH	✓	-	-	10	10	10	9	9	5	9
10	AV	-	-	-	10	10	10	10	10	-	10
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
11	GRD	-	-	-	-	-	-	-	-	-	-
12	SHIP	-	-	-	6	5	4	4	8	5	5
13	AV	-	-	-	8	7	5	7	7	4	6
14	AV	-	-	-	-	-	-	-	-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-
15	GRD	-	-	-	-	-	-	-	-	-	-
	OTH	-	-	-	-	-	-	-	-	-	-
16	[illegible]	-	✓	-	-	-	-	-	-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
17	AV	-	✓	-	6	8	8	7	9	8	8
	MG	-	-	-	-	-	-	-	-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
18	AV	-	✓	-	7	8	8	2	1	4	5
19	SHIP	-	-	-	5	7	7	10	4	3	6
20	AV	✓	✓	-	7	7	7	7	5	5	6
21	AV	-	-	-	-	-	-	-	-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-

TABLE C-8. FOM: B/E WT & VOL

COMPANY	EQUIP	EXPERIENCE			SUITABILITY						
		SPEC	ANAL	DEMO	TRANS	TRACK	DEMO	AMBIG	GEN	COST	AVE
22	MSL	✓	-	-	-	-	-	-	-	-	-
	OTH	✓	-	-	-	-	-	-	-	-	-
23	AV	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
24	AV	-	-	-	-	-	-	-	-	-	-
	GRD	-	-	-	-	-	-	-	-	-	-
	SHIP	-	-	-	-	-	-	-	-	-	-
25	OTH	✓	✓	-	9	9	8	7	7	7	8
26	AV	✓	✓	-	10	9	10	10	10	1	8
27	GRD	-	✓	✓	-	-	-	-	-	-	-
28	AV	-	✓	-	-	-	-	-	-	-	-

LIST OF ACRONYMS AND SYMBOLS

Acronym/Symbol	Definition
A	availability
$A_{B/E}$	BIT/ETE availability
BIT	built-in test
BIT/ETE	built-in test and/or external test equipment
B/E	built-in test and/or external test equipment
EFIR	erroneous fault isolation rate
ETE	external test equipment
F_B	frequency of BIT/ETE executions
FEFI	fraction of erroneous fault isolation results
FFA	fraction of false alarms
FFD	fraction of faults detected by BIT/ETE
FFD_A	fraction of all faults detected by BIT/ETE
FFD_D	fraction of detectable faults detected by BIT/ETE
FFI	fraction of faults isolated by BIT/ETE
FFP	fraction of false pulls
FFSI	fraction of false status indications
FIR(L)	fault isolation resolution
FMAB	fraction of memory allocated for BIT/ETE
FOM	figure of merit
FPR	false pull rate
GIDEP	Government Industry Data Exchange Program
LRU	line replaceable unit
$M_{CT\ i}$	repair time of the ith system component
$M_{CT\ k}$	repair time for the kth BIT/ETE component
MPSL	maintenance personnel skill level
MTBF	mean-time-between-failures
$MTBF_{B/E}$	BIT/ETE reliability
MTTR	mean-time-to-repair
$MTTR_{B/E}$	BIT/ETE maintainability
N_B	the quantity of BIT/ETE test routines
$N_{B/E}$	quantity of BIT/ETE hardware components
N_C	number of components in a system
N_R	number of RIs in the system

LIST OF ACRONYMS AND SYMBOLS (Continued)

Acronym/Symbol	Definition
Q_{BDF}	quantity of faults detected by BIT/ETE
Q_{BIF}	quantity of BIT/ETE indicated failures ($Q_{BIF} = Q_{FA} + Q_{BDF}$)
Q_{EFIR}	quantity of erroneous fault isolation results
Q_F	quantity of all faults
Q_{FA}	quantity of false alarms
Q_{FD}	quantity of faults detected by any means
Q_{FIR}	quantity of fault isolation results
Q_{GRI}	quantity of good RIs removed
Q_{IB}	quantity of faults isolated with BIT/ETE ($Q_{IB} \leq Q_{BDF}$)
Q_{IL}	quantity of detected faults isolated to ≤L RIs by BIT/ETE
Q_{NBDF}	quantity of faults that are detectable but not by BIT/ETE ($Q_{NBDF} = Q_{FD} - Q_{BDF}$)
Q_{RR}	quantity of RIs removed
Q_{UD}	quantity of undetected failures ($Q_{UD} = Q_F - Q_{FD}$)
RI	replaceable item
RMA	reliability/maintainability/availability
$\bar{S}$	the average fault isolation group size
T_B	mean BIT/ETE running time
T_{B_i}	running time of the ith BIT/ETE test routine
T_{FD}	mean fault detection time
T_{FI}	mean fault isolation time
TT	test thoroughness
α	produce risk
β	consumer risk
γ	the rate at which transients occur
δ	the rate at which out-of-tolerance conditions will occur
λ_{BF_j}	the failure rate of the jth BIT/ETE component that results in a false alarm
$\lambda_{B/E}$	failure rate of the BIT/ETE hardware
λ_{B/E_k}	failure rate of the kth BIT/ETE hardware component
λ_{D_i}	failure rate of the ith component that is detectable by BIT/ETE
λ_{d_i}	failure rate of the ith component associated with the denominator of the defined FOM

LIST OF ACRONYMS AND SYMBOLS (Continued)

Acronym/Symbol	Definition
λ_{EFI_i}	failure rate of the ith component that results in an erroneous fault isolation result
λ_{I_i}	failure rate of the ith component that is isolatable by BIT/ETE
λ_i	failure rate of the ith component
λ_j	failure rate of the jth RI or unit
λ_{LK_j}	failure rate of the jth RI associated with the L_k fault isolation resolution level
λ_{ni}	failure rate of the ith component associated with the numerator of the defined FOM
λ_{T_i}	failure rate of the ith component that is tested by BIT/ETE
λ_{UD_i}	failure rate of the ith component that is undetectable by any means
λ_{UD_j}	failure rate of the jth RI or unit that is undetectable by any means