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NOT MEASUREMENT SENSITIVE

MIL-HDBK-1814
14 February 1997
SUPERSEDING
MIL-STD-1814
NOTICE 1
14 February 1997

DEPARTMENT OF DEFENSE HANDBOOK

INTEGRATED DIAGNOSTICS

THIS HANDBOOK IS FOR GUIDANCE ONLY
DO NOT CITE THIS DOCUMENT AS A REQUIREMENT

AMSC N/A AREA GDRQ

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FOREWORD

1. This military standard is approved for use by the Aeronautical Systems Division, Department of the Air Force, and is available for use within the distribution limitations noted on the cover page.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: ASD/ENES, Wright-Patterson AFB OH 45433-6503 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This standard is one of two documents that address incorporating Integrated Diagnostics (ID) into Air Force weapon system acquisition programs. The other document is AFGS-87256.

WARNING

INFORMATION SUBJECT TO EXPORT CONTROL LAWS

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1. SCOPE

1.1 SCOPE. This standard contains generic requirements and verifications for properly incorporating integrated diagnostics (ID) into acquisition program events, such as creating documents and plans, accomplishing studies and tradeoffs, and conducting reviews and audits.

The diagnostic capability discussed in this document covers a system's ability to detect faults and to isolate the causes of those faults to provide status information upon which to base decisions, such as is an aircraft safe to fly, what needs to be replaced or repaired to restore a function, or has a component been successfully repaired.

The various appendices to this standard offer guidance on tailoring these generic requirements to fit specific programs and guidance on how to meet these requirements once applied to a program.

1.2 PURPOSE. This standard is intended for use by Air Force system acquisition managers, prime contractors, and subcontractors when they need to determine how to incorporate diagnostics into acquisition program events.

1.3 APPLICABILITY. This standard may be tailored for use on any Air Force weapon system in any acquisition phase. It covers diagnostics needed on a weapon system for mission, maintenance, and safety reasons. It applies to all activities in a weapon system acquisition in which diagnostics must be considered.

1.3.1 Application guidance. When a requirement in this standard calls for stating needed diagnostic design features, such as writing System Operational Requirements Documents or specifications, AFGS-87256 is a source of generic diagnostic capability requirements and verifications that can be tailored to fit the particular need. Figure 1 illustrates how the two ID documents relate to weapon system acquisitions.

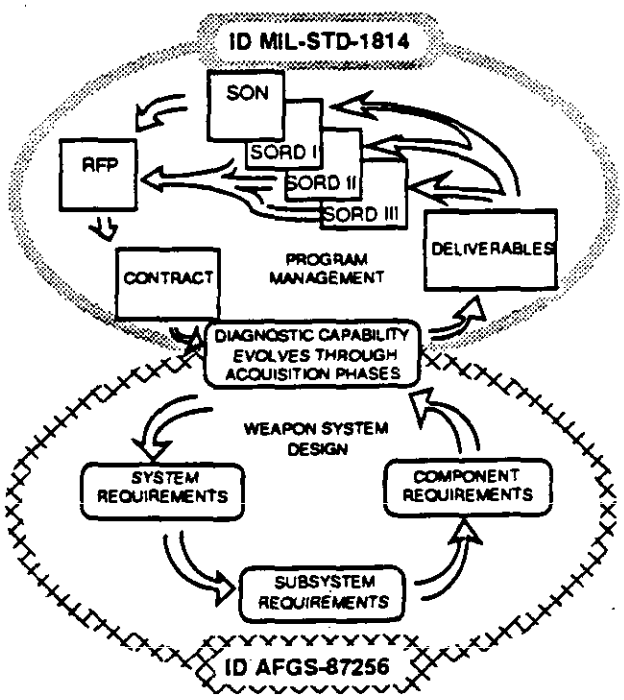


Figure 1 Integrated Diagnostic Documents and Process

This standard is structured so that a user can go directly to the sections relevant to the task at hand. The following sections explain the organization and recommended use of this standard.

1.3.1.1 Organization. This standard follows the MIL-PRIME concept. It has a main section from which contractually binding requirements and verifications may be selected and appendices with non-binding information. Appendix A repeats the requirements and verifications found in the main body, but adds rationale, application and implementation guidance, and lessons learned. Appendix I contains a Roadmap that shows how the requirements relate to acquisition program events and to each other. The Roadmap is a graphical table of contents that is central to the use of this document. The other appendices offer guidance on specific aspects of the ID process. The following are key features of this document.

1. All requirement sections begin with a 3 (i.e., 3.1.2.1).
2. All verification sections begin with a 4 (i.e., 4.1.2.1).
3. Related requirements and verifications have the same number, except for the first digit per 1 and 2 above (i.e., 3.1.2.4 and 4.1.2.4 are a requirement and its associated verification).
4. Each requirement and verification has the same number in the main body, Appendix A, and the Roadmap.

1.3.1.2 Usage. The user of this document should start at the Roadmap, Appendix I, for the specific phase and identify activities of interest. The numbers associated with each Roadmap activity would then be used to refer to the table of contents to locate the related requirement and verification statements in this standard and the rational, guidance, and lessons learned in Appendix A. Figure 2 illustrates the organization and use of this document.

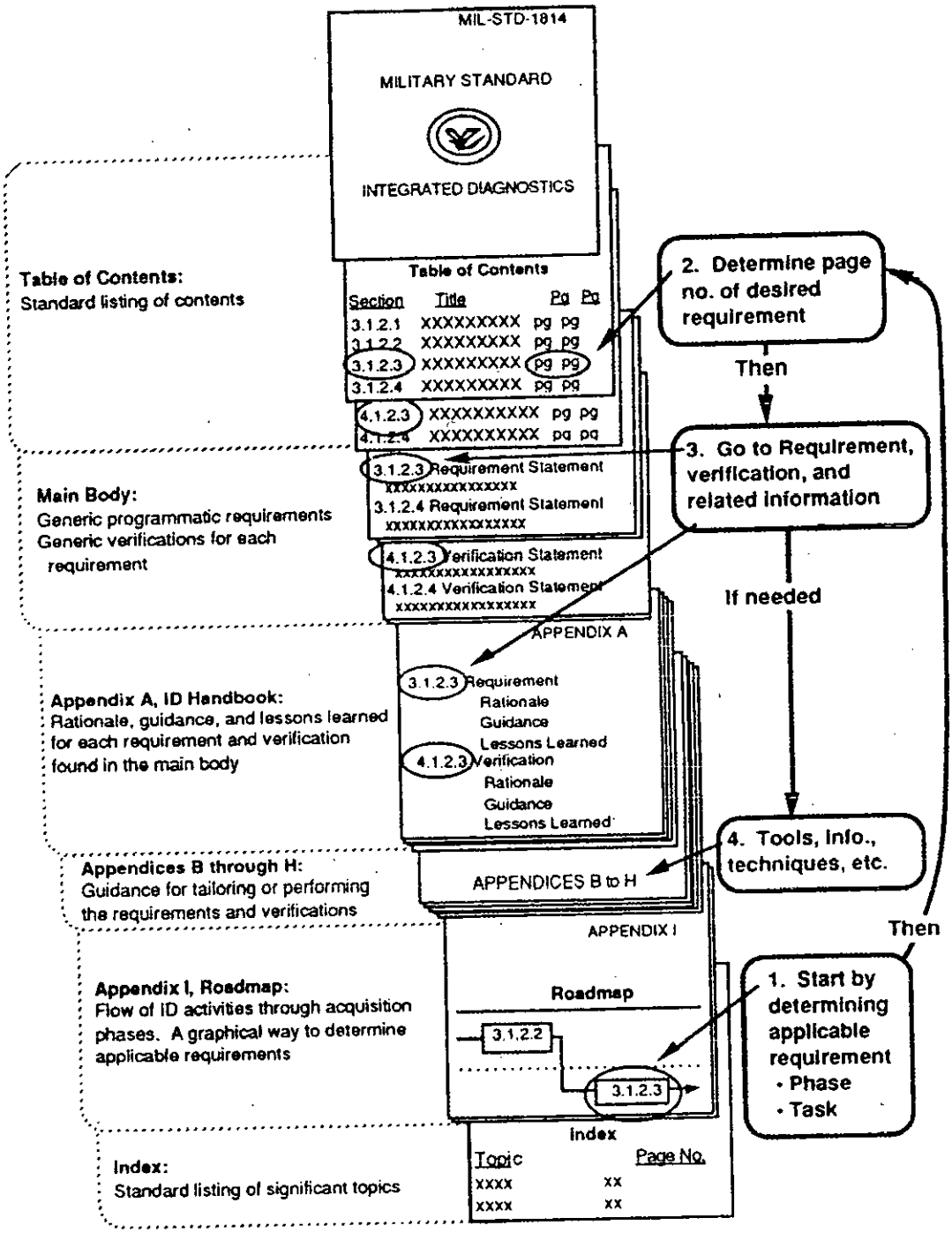


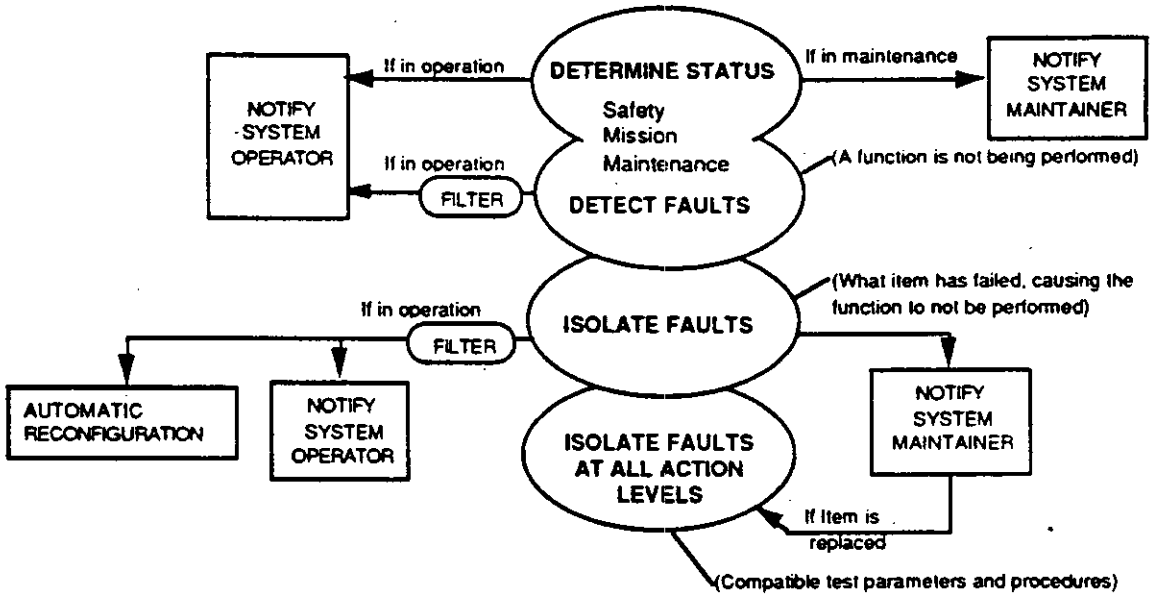
Figure 2 Organization and Use of ID MIL-STD-1814

1.3.1.3 Example. A contractor incorporating diagnostics into various plans for a program in the Concept Exploration Phase would go to the Concept Exploration section of the Roadmap, in this case p. 277, and note that the box titled "Diagnostic segments of program

plans" and annotated with 3.1.2.3 addresses the area of concern. Looking for 3.1.2.3 in the Table of Contents (p. iii) reveals that its requirement statement is on p. 7. The appendix information (rationale, guidance, lessons learned) is on p. 39. The verification statement (p. v of the table of contents) is 4.1.2.3 on p. 13 and its appendix information is on p. 40. Note that a verification is immediately behind its corresponding requirement in Appendix A, while requirements and verifications are in separate sections in the main body.

1.4 TAILORING OF REQUIREMENTS. This standard does not require the establishment of a new or separate organization for integrated diagnostics. The individual requirements should be stated so that existing engineering disciplines can implement integrated diagnostics requirements by augmenting their programs.

1.4.1 Diagnostic capability. The diagnostic capability discussed in this document covers a system's ability to detect faults and to isolate the causes of those faults to provide status information upon which to base decisions, such as is an aircraft safe to fly, what needs to be replaced or repaired to restore a function, or has a component been successfully repaired. The ability of diagnostics to provide information upon which to base decisions is an integral part of a weapons system's ability to accomplish its mission. This diagnostic capability is illustrated in Figure 3.



Operation = The period when the system is activated and not accessable to maintenance personnel.

Item = The lowest level component that can be replaced, repaired, reprogrammed or reconfigured at the specified/applicable level of maintenance, to correct the fault within any specified constraints.

Figure 3 Diagnostic Capability

1.4.2 Integrated diagnostic approach. An integrated approach to achieving a balanced diagnostic capability has the following key features.

1. The integration of embedded, support equipment, and manual techniques to provide complete coverage of diagnostic information needs

2. The integration of all needs for diagnostic information to minimize overall diagnostics required and optimize performance (Diagnostics embedded for mission reasons can store fault data useful for maintenance)

1.4.3 Integrated diagnostic process. The ID process is intended to work in a system engineering environment. It requires a team approach in which all aspects of an acquisition (performance, support, production, etc.) are considered from the beginning and addressed interactively throughout a program. Properly tailoring and applying diagnostic requirements as depicted on the Roadmap will ensure that diagnostics is considered at the proper points in an acquisition program. It is up to overall program management to ensure that the proper system engineering environment is provided so that these requirements can be satisfied.

2. APPLICABLE DOCUMENTS

2.1 GOVERNMENT DOCUMENTS

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein, Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

Military Specifications

AFGS-87256 Integrated Diagnostics (ID AFGS)

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 ORDER OF PRECEDENCE. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

The requirements stated herein address the diagnostics activities depicted in the Appendix I Roadmap. They are organized by life cycle phase, as is the Roadmap. They define the steps and procedures necessary for integrating the diagnostic pieces with each other and with the overall weapon system/equipment life cycle.

3.1 DEVELOPMENT. The Development section covers the following life cycle phases, at the indicated section numbers.

Operational Requirements (3.1.1)
Concept Exploration (3.1.2)
Demonstration and Validation (3.1.3)
Full-Scale Development (3.1.4)

3.1.1 Operational Requirements

3.1.1.1 Diagnostic inputs to the Statement of Operational Need. Diagnostic inputs to the Statement of Operational Need (SON) must be provided to establish the basis for developing the diagnostic capability.

3.1.1.2 Diagnostic inputs to the Program Management Directive. Diagnostic inputs to the Program Management Directive (PMD) must be provided to ensure that adequate attention is paid to diagnostics by the acquisition agency.

3.1.2 Concept Exploration Phase

3.1.2.1 Diagnostic segments of the Program Management Plan sections. The approach to satisfying diagnostic requirements must be included in the appropriate sections of the Air Force Program Management Plan (PMP)

3.1.2.1.a Modification planning. Include the approach to satisfying diagnostic requirements in modification plans.

3.1.2.2 Diagnostic segments of the Request For Proposal. The sections of the Request For Proposal (RFP) that address diagnostic issues shall be prepared.

3.1.2.3 Diagnostic segments of program plans. Diagnostic inputs to the various contractor-prepared management plans must be prepared.

3.1.2.3.1 Data sharing plans. The contractor shall establish and implement formal data sharing plans to ensure that functional organizations, team members, and subcontractors have access to current diagnostic development information throughout the concept exploration phase.

3.1.2.4 Diagnostic requirements derivation and allocation. Diagnostic requirements and initial diagnostic approaches based on weapon system needs shall be defined.

3.1.2.5 Diagnostic inputs to the Test and Evaluation Master Plan. Diagnostic inputs shall be incorporated into the Test and Evaluation Master Plan (TEMP).

3.1.2.6 Diagnostic capability during System Requirements Review. A review of diagnostic requirements and the analysis that lead to the selection of the preferred diagnostic approach shall be included during the System Requirements Review (SRR).

3.1.2.7 Diagnostic specifications. Diagnostic requirements resulting from the preliminary diagnostic analysis and optimization tasks shall be incorporated into the system specification or equivalent requirement documents.

3.1.2.8 Diagnostic inputs to the System Operational Requirements Document. Diagnostic inputs to the System Operational Requirements Document (SORD) must be provided to establish the basis for developing and tracking the diagnostic capability.

3.1.2.9 Diagnostic inputs to the Depot Support Requirement Document. Diagnostic inputs to the Depot Support Requirement Document (DSRD) must be provided to establish the plan and requirements for providing both Depot maintenance and material support.

3.1.2.10 Diagnostic inputs to System Concept Paper. Diagnostic inputs must be included in the System Concept Paper (SCP).

3.1.3 Demonstration/Validation (Dem/Val) Phase

3.1.3.1 Diagnostic segments of the Program Management Plan. The diagnostic segments of the Program Management Plan (PMP) shall be developed or, if previously initiated, reviewed and updated for consistency with current program direction.

3.1.3.1.a Modification planning. Include the approach to satisfying diagnostic requirements in modification plans.

3.1.3.1.1 System engineering and configuration (PMP Section 4). A requirement for diagnostics capability shall be included in the system engineering management approach included in the PMP.

3.1.3.1.2 Requirements for test and evaluation (PMP Section 5). Early planning for diagnostic Test and Evaluation shall be included.

3.1.3.1.3 Requirements for Integrated Logistics Support (PMP Section 9). The interface between integrated diagnostics and Integrated Logistics Support (ILS), from both design and support aspects, must be identified and implementation procedures must be defined.

3.1.3.1.3.1 Diagnostic inputs to the manpower and organization section of the Program Management Plan. Planning to manage the introduction of diagnostic-related manpower requirements shall be provided.

3.1.3.1.3.2 Diagnostic inputs to personnel and training section of the Program Management Plan. Plans for the training of technicians shall be devised early in the acquisition of a weapon system/equipment.

3.1.3.2 Diagnostic segments of the Request For Proposal. The various segments of a Request For Proposal (RFP) that address diagnostic issues shall be prepared.

3.1.3.3 Diagnostic segments of program plans. The contractor shall incorporate diagnostic inputs into contractor-prepared program plans.

3.1.3.3.1 Establish data sharing plans. The contractor shall establish and implement formal data sharing plans to ensure that functional organizations, team members, and subcontractors have access to current diagnostic development information throughout the Dem/Val Phase.

3.1.3.4 Diagnostic system engineering studies and analyses. Studies and analyses shall be performed to establish and define the diagnostic capability in qualitative and quantitative terms.

3.1.3.5 Diagnostic maturation and data collection. Plans for diagnostic capability performance data collection, data analysis, and corrective action shall be completed as part of the ID Program Plan.

3.1.3.6 Diagnostic segments to specifications. The results of Dem/Val effort shall be introduced into the diagnostic segments of specifications for Full Scale Development.

3.1.3.7 Diagnostic inputs to the System Operational Requirements Document. Update diagnostics inputs to the System Operational Requirements Document (SORD).

3.1.3.8 Update diagnostic inputs to the Depot Support Requirement Document. Update diagnostic inputs to the Depot Support Requirement Document (DSRD).

3.1.3.9 Diagnostic segment of System Design Review. The System Design Review (SDR) shall include a complete review of the planned development of the diagnostic capability.

3.1.3.10 Diagnostic inputs to the Test And Evaluation Master Plan. Diagnostic inputs to the Test and Evaluation Master Plan (TEMP) must be updated.

3.1.3.11 Diagnostic inputs to the Decision Coordinating Paper. Diagnostic inputs to the Decision Coordinating Paper (DCP) shall be prepared prior to authorization for beginning FSD.

3.1.4 Full-Scale Development Phase

3.1.4.1 Diagnostic segments of the Program Management Plan. Diagnostic inputs to the Program Management Plan (PMP) must be generated/updated.

3.1.4.1.a *Modification planning.* The approach to satisfying diagnostic requirements must be included in modification plans.

3.1.4.1.1 System engineering and configuration (PMP Section 4). Diagnostic capability must be included in the system engineering management approach in the PMP.

3.1.4.1.2 Test and evaluation (PMP Section 5). Test and Evaluation (T&E) shall be planned to ensure diagnostic procedures and resources are in place.

3.1.4.1.3 Integrated Logistics Support (PMP Section 9). Implementation procedures for the interface between integrated diagnostics and Integrated Logistics Support (ILS) shall be identified and defined from both design and support aspects.

3.1.4.1.3.1 Manpower and organization (PMP Section 10). Diagnostic manpower requirements shall be introduced into the Manpower and Organization Section of the PMP.

3.1.4.1.3.2 Personnel training section of PMP. Plans for training technicians shall be devised and included in the Personnel Training Section of the PMP.

3.1.4.2 Diagnostic segments of the RFP. The various segments of an RFP that address diagnostic issues shall be prepared.

3.1.4.3 Diagnostic segment of program plans. Integrated diagnostic requirements shall be incorporated into various contractor-prepared program plans.

3.1.4.3.1 Develop/Update data sharing plans. The contractor shall establish and implement formal data sharing plans to ensure that functional organizations, team members, and subcontractors have access to current diagnostic development information throughout the FSD Phase.

3.1.4.4 Diagnostic preliminary design. The contractor shall perform cohesive, integrated diagnostic design to develop the total diagnostic capability necessary to meet weapon system requirements as part of preliminary design for the prime system.

3.1.4.4.1 Diagnostic inputs to hardware and software specifications. The results of the preliminary design must be documented in the appropriate specifications.

3.1.4.5 Diagnostic data collection and maturation planning. Appropriate segments of the Diagnostic Maturation Program shall continue to be planned and implemented.

3.1.4.6 Preliminary Design Reviews. The diagnostic preliminary design shall be reviewed to ensure it meets the specified diagnostic capability for the individual configuration item (CI) or aggregate of CIs.

3.1.4.7 Diagnostic detail design. Detailed diagnostic design shall be incorporated into the design of the system/CI.

3.1.4.7.1 Design embedded diagnostics capability. Embedded diagnostic detail design shall be performed for the system, segment, element, subsystem, and assembly.

3.1.4.7.2 Interface with engineering disciplines and logistics support. The interface with other disciplines, initiated during preliminary design, shall be continued to ensure the proper integration of diagnostic elements.

3.1.4.7.3 Diagnostic inputs to hardware and software specifications. Diagnostic segments shall be developed and included in the appropriate hardware and software draft product specifications.

3.1.4.8 Diagnostic related plans. The contractor shall address relevant portions of the integrated diagnostic process and the development of the diagnostic capability in appropriate management plans.

3.1.4.8.1 Update diagnostic inputs to the Test And Evaluation Master Plan. Diagnostic input to the Test And Evaluation Master Plan (TEMP) must be updated.

3.1.4.9 Update diagnostic inputs to the System Operational Requirements Document and the Requirements Correlation Matrix. Diagnostic inputs to the System Operational Requirements Document (SORD) and the Requirements Correlation Matrix (RCM) shall be updated.

3.1.4.9.1 Update diagnostic inputs to the Depot Support Requirements Document. Diagnostic inputs to the Depot Support Requirements Document (DSRD) shall be updated.

3.1.4.10 Critical Design Review. The final design review shall ensure that all diagnostic requirements have been addressed prior to fabrication.

3.1.4.10.1 Diagnostic segments of the Test Requirements Review. The developer's readiness to begin diagnostic element-related CSCI testing shall be determined.

3.1.4.11 Fabricate and provide external diagnostic elements. External diagnostic elements shall be fabricated and provided to comply with specified requirements.

3.1.4.11.1 Offline testing capability. Offline testing capability shall be fabricated.

3.1.4.11.2 Technical information delivery systems. Technical information delivery systems shall be defined, developed, and fabricated as part of the external diagnostic capability.

3.1.4.11.3 Training. Training curriculum and training devices shall be developed concurrently with the prime system fabrication.

3.1.4.11.4 Diagnostic requirements for technical information. Succinct, accurate, and timely information shall be provided for the maintenance technician.

3.1.4.12 Diagnostic segment of Development Test and Evaluation. The diagnostic capability shall be tested and evaluated during detail design.

3.1.4.13. Maintainability demonstrations. Diagnostics shall be incorporated into maintainability demonstrations.

3.1.4.14 Diagnostic segment of Initial Operational Test and Evaluation. The overall effectiveness, operability, and suitability of the diagnostic capability shall be tested and evaluated.

3.1.4.15 Diagnostic input to Production Readiness Review. The Production Readiness Review (PRR) shall certify that the embedded diagnostic capability is ready for quantity production.

3.1.4.16 Functional Configuration Audit. The Functional Configuration Audit (FCA) shall address the embedded diagnostic capability.

3.2 PRODUCTION

3.2.1 Maturation inputs to production RFP. Inputs to the Production Phase RFP should be prepared relative to the maturation of the diagnostic capability.

3.2.2 Diagnostic segment of Follow-on Operational Test and Evaluation. Diagnostic Follow-on Operational Test and Evaluation (FOT&E) shall verify that first article production items meet diagnostic requirements.

3.2.3 Diagnostic segments of Physical Configuration Audits. Requirements, guidance documents, and procedures to conduct Physical Configuration Audits (PCAs) shall be defined for the embedded diagnostic segments of configuration items.

3.2.4 Diagnostic production data collection and maturation. Requirements established during the preproduction acquisition phases for diagnostic elements data collection and maturation shall be implemented during the Production Phase.

3.2.4.1 Establish/update data sharing plans. The contractor shall establish and implement, or update, formal data sharing plans to ensure that functional organizations, team members, and subcontractors have access to current diagnostic development information throughout the production phase.

3.2.4.2 Update vertical test traceability matrix. Organizational, depot, and intermediate TRDs, including VTTM, that document test relationships between levels of test shall be updated.

3.2.4.3 Diagnostic performance assessment and evaluation. Performance of the diagnostic elements on the production line shall be assessed and evaluated, and needed corrective action shall be defined.

3.2.5 Change approval process. Identified diagnostic element performance deficiencies shall be corrected and the impact of system design changes on the diagnostic capability shall be considered.

3.2.6 Program management responsibility transfer. All diagnostic elements shall be included in the Program management responsibility transfer (PMRT) and responsibility for continued engineering management and logistic support shall be assigned.

3.3 DEPLOYMENT

3.3.1 Deployed diagnostic element performance assessment. A method for identifying and tracking diagnostic element performance during deployment shall be established by implementing data collection and maturation plans developed during the Development and Production Phases in concert with Milestone IV, Logistic Readiness and Support Reviews.

3.3.1.1 Deployed diagnostic element corrective action. Procedures and guidance for implementing diagnostic deficiency corrective action shall be provided.

4. VERIFICATIONS. For each requirement included in this standard, a corresponding verification is provided to determine compliance with the requirement.

4.1 DEVELOPMENT

4.1.1 Operational Requirements

4.1.1.1 Diagnostic inputs to the Statement of Operational Need. Verify that appropriate diagnostic inputs are included by inspecting the SON/RCM and MNS.

4.1.1.2 Diagnostic inputs to the Program Management Directive. Verify that appropriate diagnostic tasking is included in the PMD.

4.1.2 Concept Exploration Phase

4.1.2.1 Diagnostic segments of the Program Management Plan sections. Verify that the diagnostic pieces have been incorporated by inspecting the PMP.

4.1.2.1.a Modification planning. Verify by inspection that diagnostic implications have been addressed in the TCTO.

4.1.2.2 Diagnostic segments of the Request For Proposal. Verify that appropriate diagnostic segments and provisions are in the Concept Exploration RFP, including the SOW, the Evaluation Criteria, and the Instructions to Offerors, by inspecting these documents.

4.1.2.3 Diagnostic segments of program plans. Verify that the integrated diagnostic process has been injected into the SEMP, the LSAP, the ISP, or the IDPP by inspecting these documents.

4.1.2.3.1 Data sharing plans. The formal data sharing plan and implementation shall be verified by inspection.

4.1.2.4 Diagnostic requirements derivation and allocation. Verify by checklist evaluation that the weapon system diagnostic requirements and diagnostic approaches for entering Dem/Val are based upon weapon system needs.

4.1.2.5 Diagnostic inputs to the Test and Evaluation Master Plan. Verify that adequate diagnostic inputs have been made to the TEMP.

4.1.2.6 Diagnostic capability during System Requirements Review. Verify by analysis that proper methods are used to ensure that the diagnostic segment of the SRR will correctly evaluate the preliminary diagnostic concept of the emerging system/equipment.

4.1.2.7 Diagnostic specifications. Verify that diagnostic inputs have been made to the system specification or equivalent requirement documents by inspecting these documents.

4.1.2.8 Diagnostic inputs to the System Operational Requirements Document. Verify that appropriate diagnostic inputs are included by inspecting the SORD and the RCM.

4.1.2.9 Diagnostic inputs to the Depot Support Requirement Document. Verify that appropriate diagnostic inputs are included by inspecting the DSRD.

4.1.2.10 Diagnostic inputs to System Concept Paper. Verify by checklist evaluation that the diagnostic impact on SCP issues, defined in DoD documents, is included in the SCP.

4.1.3 Demonstration/Validation (Dem/Val) Phase

4.1.3.1 Diagnostic segments of the Program Management Plan. Verify by inspection that the diagnostic requirements have been incorporated in the applicable sections of the PMP.

4.1.3.1.a Modification planning. Verify by inspection that diagnostic implications have been addressed in the TCTO.

4.1.3.1.1 System engineering and configuration (PMP Section 4). Verify by inspection that this section of the PMP is correct.

4.1.3.1.2 Requirement for test and evaluation (PMP Section 5). Verify by inspection that central issues, areas of risk, and specific test objectives for diagnostic T&E have been appropriately identified and incorporated into the PMP, Section 5.

4.1.3.1.3 Requirement for Integrated Logistics Support (PMP Section 9). Verify by inspection that pertinent diagnostic information is incorporated into ILS (Section 9) of the PMP in the appropriate context and level of detail so that a definitive, coordinated diagnostic program is documented.

4.1.3.1.3.1 Diagnostic inputs to the manpower and organization section of the Program Management Plan. Verify that diagnostic requirements relating to manpower and organization have been included by inspecting the PMP.

4.1.3.1.3.2 Diagnostic inputs to personnel and training section of the Program Management Plan. Verify by inspection that the Program Management Plan contains adequate emphasis on personnel training for troubleshooting and maintenance.

4.1.3.2 Diagnostic segments of the Request For Proposal. Verify by inspection that appropriate diagnostic segments and provisions are in the Dem/Val RFP, including the SOW, Special Contract Requirements, Evaluation Criteria, and Instructions to Offerors.

4.1.3.3 Diagnostic segments of program plans. Verify that the integrated diagnostic process has been included in the SEMP, IDPP, and into other relevant plans by inspecting these documents.

4.1.3.3.1 Establish data sharing plans. The formal data sharing plan and implementation shall be verified by inspection.

4.1.3.4 Diagnostic system engineering studies and analyses. Verify by inspection that the weapon system design process includes quantitative values for the diagnostic segments at both system and configuration item levels and that the appropriate tradeoffs have been accomplished. Include assessment of the quality of these studies and analyses.

4.1.3.5 Diagnostic maturation and data collection. Verify by inspection that the contractor's approach to diagnostic data collection and maturation is comprehensive and realistically scheduled.

4.1.3.6 Diagnostic segments to specifications. Verify that diagnostic inputs have been made to the system specifications by inspection.

4.1.3.7 Diagnostic inputs to the System Operational Requirements Document. Verify that appropriate diagnostic inputs are included by inspecting the SORD and RCM.

4.1.3.8 Updating of diagnostic inputs to the Depot Support Requirements Document. Verify that appropriate updates of diagnostic inputs are included by inspecting the DSRD.

4.1.3.9 Diagnostic segment of the System Design Review. Verify by inspection that the proper methods are used to ensure that the diagnostics segment of the SDR will correctly evaluate the preliminary diagnostic concept of the emerging system/equipment.

4.1.3.10 Diagnostic inputs to the Test and Evaluation Master Plan. Verify the adequacy of diagnostic inputs that have been made to the TEMP.

4.1.3.11 Diagnostic inputs to the DCP. Verify by inspection that the impact of the diagnostic capability is included in the DCP.

4.1.4 Full-Scale Development Phase

4.1.4.1 Diagnostic segments of Program Management Plan. Verify that diagnostic requirements have been incorporated by inspecting applicable sections of the PMP.

4.1.4.1.a Modification planning. Verify by inspection that diagnostic implications have been addressed in the TCTO.

4.1.4.1.1 System engineering and configuration (PMP Section 4). Verify that the System Engineering and Configuration section of the PMP addresses diagnostic elements by inspecting the document.

4.1.4.1.2 Test and evaluation (PMP Section 5). Verify that central issues, areas of risk, and specific test objectives for diagnostics T&E have been appropriately identified and incorporated by inspecting the PMP, Section 5.

4.1.4.1.3 Integrated Logistics Support (PMP Section 9). Verify that pertinent diagnostic information is incorporated into the ILSP or ILS, Section 9, of the PMP, by inspecting this section.

4.1.4.1.3.1 Manpower and organization (PMP Section 10). Verify that diagnostic requirements relating to manpower and organization have been established by inspecting the PMP, section 10.

4.1.4.1.3.2 Personnel training section of PMP. Verify by inspection that the PMP contains adequate emphasis on personnel training for troubleshooting and maintenance.

4.1.4.2 Diagnostic segments of RFP. Verify adequacy and completeness of the diagnostic input by inspecting the FSD RFP.

4.1.4.3 Diagnostic segment of program plans. Verify by inspection that the integrated diagnostic process has been included in the SEMP, IDPP, and into other relevant plans.

4.1.4.3.1 Develop/Update data sharing plans. The formal data sharing plan and implementation shall be verified by inspection.

4.1.4.4. Diagnostic preliminary design. Verify by analysis and inspection that the appropriate preliminary design tasks related to diagnostics have been satisfactorily addressed.

4.1.4.4.1 Diagnostic inputs to hardware and software specifications. Verify by inspection that the results of the diagnostics preliminary design are documented in the revised versions of the appropriate development specifications.

4.1.4.5 Diagnostic data collection and maturation planning. Verify diagnostic data collection and maturation plans by inspection and analysis.

4.1.4.6 Preliminary Design Reviews. Verify by inspection that the preliminary design review agenda contains items for reviewing the diagnostic capability of each CI.

4.1.4.7 Diagnostic detail design. Verify that the incorporation of diagnostic capability is accomplished in a comprehensive, timely, efficient, and cost-effective manner by conducting in-process reviews.

4.1.4.7.1 Design embedded diagnostic capability. Verify that the incorporation of the embedded diagnostic detail design is accomplished in a timely, efficient, and cost-effective manner by conducting in-process reviews.

4.1.4.7.2 Interface with engineering disciplines and logistic support. Verify that the interfacing tasks initiated during preliminary design are continued through detail design by conducting inspections and in-process reviews.

4.1.4.7.3 Diagnostic input to hardware and software specifications. Verify that the results of the diagnostics detail design are documented in the revised versions of the appropriate development specifications by inspecting the specifications.

4.1.4.8 Diagnostic related plans. Verify that the integrated diagnostic process has been incorporated into the SEMP and into other relevant plans by evaluating these documents.

4.1.4.8.1 Update diagnostic inputs to the Test And Evaluation Master Plan. Verify by inspection that diagnostic inputs have been made to the TEMP.

4.1.4.9 Update diagnostics inputs to the System Operational Requirements Document and the Requirements Correlation Matrix. Verify that appropriate updating of diagnostic inputs are included by inspecting the SORD and RCM.

4.1.4.9.1 Update diagnostic inputs to the Depot Support Requirements Document. Verify that appropriate updates of diagnostic inputs are included by inspecting the DSRD.

4.1.4.10 Critical Design Review. Verify that the detail design of the system CIs is evaluated for their specified diagnostic capability during the CDR.

4.1.4.10.1 Diagnostic segments of the Test Requirements Review. Verify that the system test documentation and specifications are current, technically accurate, compatible, and consistent prior to development and fabrication of diagnostic elements through review of test requirements.

4.1.4.11 Fabricate and provide external diagnostic elements. Verify development of maintenance diagnostic elements and the support infrastructure by reviewing fabrication process.

4.1.4.11.1 Offline testing capability. Verify the fabrication of offline testing capability by reviewing data and tools employed.

4.1.4.11.2 Technical information delivery systems. Verify that technical information delivery systems meet their intended function by reviewing development specifications.

4.1.4.11.3 Training. Verify that training requirements are satisfied in the fabrication of the prime system through review and evaluation.

4.1.4.11.4 Diagnostic requirements for technical information. Verify diagnostic requirements for technical information through analysis.

4.1.4.12 Diagnostic segment of Development Test and Evaluation. Verify that diagnostics DT&E testing and engineering analysis functions have been adequately and definitively performed through checklist evaluation.

4.1.4.13 Maintainability demonstrations. Verify by checklist evaluation of demonstration results that the diagnostics portion of the maintainability demonstration has provided a valid verification of the effectiveness of the diagnostic capability.

4.1.4.14 Diagnostic segment of Initial Operational Test and Evaluation. Verify by checklist evaluation that the diagnostic IOT&E have provided a valid estimate of the operational effectiveness and suitability of the diagnostic capability.

4.1.4.15 Diagnostic input to Production Readiness Review. Verify by check list that the various diagnostic elements are ready for production.

4.1.4.16 Functional Configuration Audit. Verify that the diagnostic capability is validated prior to the production of applicable CI/CSCIs by reviewing applicable documents.

4.2 PRODUCTION

4.2.1 Maturation inputs to production RFP. Verify adequacy and completeness of maturation inputs by inspecting the Production Phase RFP.

4.2.2 Diagnostic segment of Follow-on Operational Test and Evaluation. Verify that the diagnostics FOT&E have validated the suitability of the diagnostic capability of the first production items of the system through checklist evaluation and testing.

4.2.3 Diagnostic segments of Physical Configuration Audits. Verify that the diagnostic segment of the PCA has been satisfactorily accomplished by reviewing the PCA agenda and related data.

4.2.4 Diagnostic production data collection and maturation. Verify by inspection that a diagnostic maturation program plan is continued during the production of the embedded diagnostic elements.

4.2.4.1 Establish/update data sharing plans. The formal data sharing plan and implementation shall be verified by inspection.

4.2.4.2 Update vertical test traceability matrix. Verification is accomplished by analysis and formal demonstration.

4.2.4.3 Diagnostic performance assessment and evaluation. Verify by testing that an assessment of the diagnostic elements capability is performed during the system/subsystem/ CI production test phase and verify that proper corrective actions are taken.

4.2.5 Change approval process. Verify through inspection that the change process for correcting diagnostic deficiencies is implemented.

4.2.6 Program management responsibility transfer. Verify through checklist evaluation that the PMRT for the diagnostic elements has been accomplished.

4.3 DEPLOYMENT

4.3.1 Deployed diagnostic element performance assessment. Verify diagnostic element performance in the field by assessing the implementation of the maturation plan.

4.3.1.1 Deployed diagnostic element corrective action. Verify through checklist evaluation implementation of the diagnostic deficiency corrective action.

5. DEFINITIONS AND ABBREVIATIONS

5.1 DEFINITIONS. Terms used throughout this document are defined below. Additional definitions are included in the AFGS-87256.

Diagnosis - The functions performed and the techniques used in determining and isolating the cause of malfunctions.

Diagnostics - Anything relating to or used in making a diagnosis.

Diagnostic accuracy - The degree of correctness with which the diagnostic output agrees with the true state of the item being diagnosed.

Diagnostic capability - All the diagnostic characteristics associated with the detection, isolation, and reporting of faults.

Diagnostic element - Any distinct, single part of the diagnostic capability, e.g., automatic and manual testing, training, maintenance aiding, and technical information.

Embedded diagnostics - That portion of the diagnostic capability that is an integral part of the prime item.

Integrated Diagnostics - A structured process that maximizes the effectiveness of diagnostics by integrating pertinent elements, such as testability, automatic and manual testing, training, maintenance aiding, and technical information, as a means for providing a cost effective capability to detect and isolate unambiguously all faults known or expected to occur in weapon systems and equipment in order to satisfy weapon system mission requirements.

100 percent diagnostics - The concept by which all faults can be isolated to the level appropriate to perform required maintenance.

Testability - A design characteristic which allows the status, (i.e., operable, degraded, or inoperable) of an item to be determined in a timely manner.

5.2 ABBREVIATIONS.

A	Availability
AF	Air Force
AFB	Air Force Base
AFGS	Air Force Guide Specification
AFLC	Air Force Logistics Command
AFLCM	Air Force Logistics Command Manual
AFLCR	Air Force Logistics Command Regulation
AFR	Air Force Regulation
AFSC	Air Force Systems Command
AFSCM	Air Force Systems Command Manual
AFSCP	Air Force Systems Command Pamphlet
AFTO	Air Force Technical Order
AIS	Avionics Intermediate Shop
AMSDL	Acquisition Management Systems and Data Requirements Control List
APCD	Accuracy Performance Control Document
ASD	Aeronautical Systems Division
ASD/ENE	Aeronautical Systems Division Engineering
ASW	Antisubmarine Warfare

ATE	Automatic Test Equipment
ATLAS	Abbreviated Test Language for All Systems
ATP	Automatic Test Program
ATPG	Automatic Test Program Generator
ATS	Acceptance Test Specification
BCM	Beyond Capability of Maintenance
BIT	Built In Test
BITE	Built In Test Equipment
BIT/SIT	Built In Test/System Integrated Test
BIT/ST	Built In Test/Self Test
CADC	Central Air Data Computer
CAE	Computer Aided Engineering
CALS	Computer Aided Acquisition and Logistics
CAMS	Core Automated Maintenance System
CCB	Configuration Control Board
CDR	Critical Design Review
CDRL	Contractor Data Requirements List
CFE	Contractor Furnished Equipment
CGM	Computer Graphics Metafile
CI	Configuration Item
CMRS	Calibration and Measurements Requirements Summary
CND	Cannot Duplicate
COMO	Combat Oriented Maintenance Organization
CONUS	Continental United States
CSC	Computer Software Component
CSCI	Computer Software Configuration Item
CSD	Computer System Diagnostic
CT	Commercial Tester
DC	Direct Current
DCP	Decision Coordinating Paper
DD	Department of Defense (used on forms only)
Dem/Val	Demonstration Validation
DI	Data Item
DID	Data Item Description
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DSRD	Depot Support Requirements Document
DSS	Decision Support System
DT&E	Development Test and Evaluation
EAR	Export Administrative Regulation
ECCM	Electronic Counter Countermeasures
ECM	Electronic Countermeasures
ECP	Engineering Change Proposal
EDIF	Electronic Design Interchange Format
EET	Engineering Evaluation Testing
Elect	Electrical or Electronic
FCA	Functional Configuration Audit
FD/FI	Fault Detection/Fault Isolation
Fed-Std	Federal Standard
FIM	Failure Isolation Manual
FMEA	Failure Mode and Effects Analysis
FMECA	Failure Modes, Effects and Criticality Analysis
FOL	Forward Operating Location

FOT&E	Follow-on Operational Test and Evaluation
FRACAS	Failure Reporting Analysis, and Corrective Action System
FRM	Failure Reporting Manual
FSD	Full Scale Development
FSE	Factory Support Equipment
FSR	Field Service Report
GFE	Government Furnished Equipment
GIMADS	Generic Integrated MAintenance DiagnosticS
HDBK	Handbook
HITS	Hierarchical Integrated Test Simulation
HQ	Headquarters
HWCI	Hardware Configuration Item
ID	Integrated Diagnostics
I&D	Intermediate and Depot
IDPP	Integrated Diagnostics Program Plan
IGES	Initial Graphics Exchange Specification
I-level	Intermediate level
ILS	Integrated Logistics Support
ILSP	Integrated Logistics Support Plan
IMIS	Integrated Maintenance Information System
IMPACTS	Integrated Manpower, Personnel, and Comprehensive Training and Safety
INST	Instruction
INU	Inertial Navigation Unit
I/O	Input/Output
IOT&E	Initial Operational Test and Evaluation
ISO	International Standards Organization
ISP	Integrated Support Plan
ITA	Interface Test Adapter
ITAR	International Traffic in Arms Regulation
ITO	Instructions To Offerors
ITP	Integrated Test Plan
JSTARS	Joint Surveillance Target Attack Radar System
LCC	Life Cycle Cost
LOG	Logistics
LOGMOD	LOGic MODel by Detex Systems, Inc.
LPRF	Low Power Radio Frequency
LRM	Line Replaceable Module
LRU	Line Replaceable Unit
LSA	Logistics Support Analysis
LSAP	Logistics Support Analysis Plan
MATE	Modular Automatic Test Equipment
MCR	Multi-Command Regulation
M-demo	Maintainability demonstration
MFL	Maintenance Fault List
MFTBF	Mean Flight Time Between Failures
MIL-SPEC	Military Specification
MIL-STD	Military Standard
MMH	Maintenance Manhours
MMH/FH	Maintenance Manhours per Flight Hour
MNS	Mission Need Statement
MOB	Main Operating Base
MPA	Modification Proposal and Analysis
MPTS	Manpower, Personnel, Training, and Safety

MPWR	Manpower
MTBF	Mean Time Between Failures
MTBM	Mean Time Between Maintenance
MTE	Manual Test Equipment
MTTR	Mean Time To Repair
NIST	National Institute of Standards and Technology
NMCM	Not Mission Capable for Maintenance
NMCMS	Not Mission Capable for Maintenance/Supply
O&M	Operation and Maintenance
OFP	Operational Flight Program
O, I & D	Organizational, Intermediate and Depot
O-level	Organizational level
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
PAVE PILLAR	Advanced Avionics Systems Architecture Program
PCA	Physical Configuration Audit
PDR	Preliminary Design Review
PI	Product Improvement
P3I	Preplanned Product Improvement
PMD	Program Management Directive
PMP	Program Management Plan
PMRT	Program Management Responsibility Transfer
PMRTWG	PMRT Working Group
P/N	Part Number
POMO	Production Oriented Maintenance Organization
PPAC	Product Performance Agreement Center
PPBS	Planning, Programming, and Budgeting System
P^3	PrePlanned Product (Improvement)
PRR	Production Readiness Review
PSOC	Preliminary System Operational Concept
R&M	Reliability and Maintainability
RCM	Requirements Correlation Matrix
RDA	Requirements Derivation and Allocation Process
RDGT	Reliability Development/Growth Test
REMIS	Reliability and Maintainability Information System
RFP	Request For Proposal
RLA	Repair Level Analysis
RSS	Root Sum of Squares
RTOK	Retest Okay
SACR	Strategic Air Command Regulation
SCP	System Concept Paper
SDR	System Design Review
SE	Support Equipment
SEMP	System Engineering Management Plan
SEMS	System Engineering Master Schedule
SEP	Support Equipment Plan
SERD	Support Equipment Recommendation Data
SGML	Standard Generalized Market Language
SIT	System Integrated Test or System Integration Test
SMR	Source, Maintenance, Recoverability
SON	Statement of Operational Need
SORD	System Operational Requirements Document
SOW	Statement of Work
SPO	System Program Office

SPO/SM	SPO/System Manager
SRR	System Requirement Review
SRU	Shop Replaceable Unit
ST/BIT	Self Test/BIT
STAMP™	System Testability And Maintenance Program by ARINC
STS	System Test Specification
Sys	System
TAR	Test Accuracy Ratio
T&E	Test and Evaluation
TBD	To Be Determined
TCTO	Time Compliance Technical Order
TEMP	Test and Evaluation Master Plan
TFD	Test Flow Diagram
TIDS	Technical Information Delivery System
T.O.	Technical Order
TPS	Test Program Set
TRD	Test Requirements Document
TRR	Test Requirements Review
TWT	Traveling Wave Tube
US	United States
USAF	United States Air Force
UUT	Unit Under Test
V	Volts
VDC	Volts Direct Current
VDE	Verify, Demonstrate and Evaluate
Vech	Vehicle
VHDL	VHSIC Hardware Description Language
VIP	Very Important Person
VTM	Vertical Test Methods
VTTM	Vertical Test Traceability Matrix
W/S	Weapon System

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 INTENDED USE. This standard is intended for use by Air Force system acquisition managers, prime contractors, and subcontractors when they need to determine how to incorporate diagnostics into acquisition program events.

6.2 ISSUE OF DODISS. When this standard is used in acquisition, the applicable issue of the DODISS must be cited in the solicitation (see 2.1.1).

6.3 DATA REQUIREMENTS. The following Data Item Descriptions (DID's) must be listed, as applicable, on the Contract Data Requirements List (DD Form 1423) when this standard is applied on a contract, in order to obtain the data, except where DOD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

Reference Paragraph	DID Number	DID Title	Suggested Tailoring
.	.	.	.
.	.	.	.

The above DID's were those cleared as of the date of this standard. The current issue of DOD 5010.12-L, Acquisition Management Systems and Data Requirements Concrol List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

6.4 SUBJECT (KEY WORD) LISTING.

BIT
CALS
GIMADS
Maintainability
MATE
SEMP
System engineering
System safety

6.5 Responsible engineering office. The office responsible for development and technical maintenance of ths standard is ASD/AEGB, Wright-Patterson AFB OH 45433-6503; Autovon 785-2350, commercial (513) 255-2350. Information relating to Government contracts must be obtained through contracting officers.

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APPENDIX A

10. ACQUISITION PROCESS HANDBOOK

10.1 SCOPE. This appendix provides rationale, guidance, and lessons learned for the generic requirements and verifications in 3 and 4 of the main body. This appendix may be tailored for use on any USAF weapon system in any acquisition phase.

10.1.1 Purpose. This appendix features information useful for establishing or complying with programmatic integrated diagnostic (ID) requirements.

10.1.2 Application. This appendix is not contractually binding. The information contained herein is intended to help tailor requirements for specific programs or to help comply with requirements once they have been applied to a program. Methods, tools, techniques, or procedures stated in this handbook are to be used for guidance only. This appendix is not intended to limit creativity in satisfying integrated diagnostic requirements.

Each requirement and verification statement in the main body is repeated in this handbook under the same section numbers. However, each verification statement has been placed immediately after its corresponding requirement. Rationale, guidance, and lessons learned are provided, as appropriate, after each requirement or verification statement .

The top-level breakdown is shown below.

SECTION NO.	SUBJECT
3.1	Development
3.1.1	Operational Requirements
3.1.2	Concept Exploration
3.1.3	Demonstration and Validation (Dem/Val)
3.1.4	Full-Scale Development (FSD)
3.2	Production
3.3	Deployment

10.1.3 Implementation guidance. The integrated diagnostics program does not constitute a new engineering specialty discipline. A special organizational structure is not necessary nor desired under normal program conditions.

The individual guidance sections emphasize the use of existing system engineering programs and specialty engineering processes (tradeoffs, allocations, etc.), such as a System Engineering Management Plan (SEMP), as a means for planning the integration of diagnostic design and engineering activities and the incorporation of diagnostic requirements analysis as part of the Logistic Support Analysis. For example, MIL-STD-1388-1, Task 204, Technological Opportunities, would be particularly appropriate in Concept Exploration or Demonstration and Validation. Integrated diagnostic activities must be included. As one other example, the Failure Modes, Effects, and Criticality Analysis should be modified to support the prediction of faults or other events, and their frequency, that will have diagnostic significance.

10.1.4 System/Equipment Modifications. This handbook and the Appendix I Roadmap focus on new weapon system/equipment developments (new starts). Managing changes to existing systems requires special emphasis on integration, implementation, and baseline control. Entry points have been provided so the ID process can begin in any acquisition phase. These entry points can also be used for weapon system and equipment modifications.

10.1.4.1 Types of product improvement. There are two types of product improvement.

Product Improvement (PI). PIs are applied to already fielded systems in response to a variety of reasons. PIs start no sooner than the Production Phase.

Preplanned Product Improvement (P^3I). P^3I is an attempt to field low-cost, low risk systems with preplanned design modifications keyed to forseeable technological breakthroughs and expected changes in user needs. P^3I planning can begin as early as the Concept Exploration Phase.

10.1.4.2 Modification application. ID process Roadmap entry points vary, depending on the classification and extent of the modification. There are no standard criteria for where to enter the ID process for each type of modification. Table 1 should be a general guide.

Table 1 Modification Classes and Roadmap Entry Points

CLASS	DESCRIPTION	ENTRY
Class I	Major commands make Class I modifications to prepare for special missions	n/a
Class I A	Temporary removal of equipment	n/a
Class I B	Temporary change or installation of equipment	n/a
Class II	Temporary research and development, operational testing and evaluation, or engineering evaluation and in-service testing modifications	n/a
Class III	Modifications to correct deficiencies detected in production, testing, and early operational use	FSD
Class IV	Correct deficiencies or extend service life of in-service weapon systems	Dem/Val
Class IV A	Correct material deficiencies	Dem/Val
Class IV B	Correct deficiencies that hamper mission effectiveness	Dem/Val
Class IV C	Modifications that improve reliability or maintainability	Dem/Val
Class V	Modifications that add new or improved operational capabilities or remove existing but unneeded capabilities	Concept Exploration

The user may choose to skip diagnostic activities previously undertaken or to modify the product of an activity as deemed appropriate.

10.2 APPLICABLE DOCUMENTS

(NOTE: These documents are not to be applied contractually except to the extent that specific portions are cited in the requirement statements or verification statements.)

10.2.1 Government documents

DoD INST 4151.9	DoD Technical Manual Program Management
DoDD 5000.3	Test and Evaluation
DoDD 5000.53	Manpower, Personnel, Training, and Safety (MPTS) in the Defense System Acquisition Process

10.2.1.1 Specifications, standards, and handbooks

SPECIFICATIONS

MIL-D-28000	Digital Representation for Communication of Product Data: IGES Application Subsets
MIL-M-28001	Markup Requirement and Generic Style Specification for Electronic Printed Output and Exchange of Text
MIL-R-28002	Requirements for Raster Graphics Representation in Binary Format
MIL-D-28003	Digital Representation for Communication of Illustration Data: CGM Application Profile
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment, and Facilities
AFGS-87256	Integrated Diagnostics

STANDARDS

MIL-STD-470	Maintainability Program for System and Equipment
MIL-STD-471A	Maintainability Demonstration
MIL-STD-480	Configuration Control - Engineering Changes, Deviations and Waivers
MIL-STD-481	Configuration Control - Engineering Changes (Short Form), Deviations and Waivers
MIL-STD-482	Configuration Status Accounting Data Elements and Related Features
MIL-STD-483	Configuration Management Practices for Systems, Equipment, Munitions, and Computer Programs
MIL-STD-490	Specification Practices
MIL-STD-499	Engineering Management
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-882	System Safety Program Requirements
MIL-STD-1388-1	Logistic Support Analysis
MIL-STD-1388-2	DoD Requirements for a Logistics Support Analysis Record

MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities
MIL-STD-1519	Test Requirements Document, Preparation of
MIL-STD-1629	Procedures for Performing a Failure Mode, Effects, and Criticality Analysis
MIL-STD-1685 (SH)	Comprehensibility Standards for Technical Manuals (Metric)
MIL-STD-1752 (USAF)	Reading Level Requirements for Preparation of Technical Orders.
MIL-STD-1840A	Automated Interchange of Technical Information
MIL-STD-2155	Failure Reporting, Analysis, and Corrective Action System
MIL-STD-2165	Testability Program for Electronic Systems and Equipment
DoD-STD-2167	Defense System Software Development

10.2.1.2 Other Government documents, drawings, and publications

AFP-57-9	Defining Logistics Requirements in Statement of Need
AFR-14-1	Configuration Management
AFR-57-1	Operational Needs, Requirements, and Concepts
AFR 57-4	Modification Approval and Management
AFR 70-11	Weapon System Warranties
AFR 80-14	Research and Development Test and Evaluation
AFR 800-2	Acquisition Program Management
AFR-800-8	Integrated Logistics Support Program
AFR 800-12	Acquisition of Support Equipment
AFSCP 800-3	A Guide for Program Management
AFSC/AFLCR 800-23	Policy for Modular Automatic Test Equipment
AFSC-PAM 800-39	Built-in-Test Design Guide
AFLC/AFSCP 800-34	Acquisition Logistic Management

10.3 GENERAL REQUIREMENTS. This appendix provides guidance for tailoring and applying the requirements and verifications in this standard.

10.4 DETAILED REQUIREMENTS. Detailed requirements are contained in 3 and 4 of this standard. Each requirement is repeated in this appendix.

10.5 REQUIREMENTS AND VERIFICATIONS.

Note: Numbering below deviates from the numbering scheme used up to this point in this handbook. To aid crossreferencing between requirement and verification statements in the main body and the corresponding information in this handbook, the same section numbers are used for each requirement and verification below as was used in the main body, 3 and 4. Additionally, each verification is placed at the end of its corresponding requirement rather than in a separate section.

3. REQUIREMENTS. The requirements address the diagnostic activities depicted in the Roadmap (Appendix I). They define the steps and procedures necessary to integrate the diagnostic elements with each other and with the overall weapon system or equipment life cycle.

4. VERIFICATIONS. For each requirement included in this standard, a corresponding verification is provided to determine compliance with the requirement. Verifications are placed immediately behind their corresponding requirement in this handbook.

3.1 DEVELOPMENT. The Development section contains the following life cycle phases.

SECTION NO.	PHASE
3.1.1	Operational Requirements
3.1.2	Concept Exploration
3.1.3	Demonstration and Validation (Dem/Val)
3.1.4	Full-Scale Development (FSD)

3.1.1 Operational Requirements

3.1.1.1 Diagnostic inputs to the Statement of Operational Need. Diagnostic inputs to the Statement of Operational Need (SON) must be provided to establish the basis for developing the diagnostic capability.

Requirement Rationale

The SON states the operational need for a new weapon system. Proper SON provisions can provide the foundation for developing a diagnostic capability that supports the user's needs, while allowing contractors to be creative in meeting these needs.

Requirement Guidance

Use AFR-57-1 Operational Needs, Requirements, and Concepts, as a guide. A SON defines an operational need, documents validation of the need, and furnishes preliminary requirements. A Requirements Correlation Matrix (RCM) is attached to the SON. The RCM lists parameters and requirements that the weapon system must have to accomplish its intended mission. The RCM is used to document and track formulation and refinement of these user requirements as they evolve through the program acquisition process.

The SON should contain a concise statement of the desired diagnostic capability in terms that are supported or clarified by parameters in the RCM. The RCM parameters should provide mission and maintenance oriented requirements and goals that can be used in system engineering trade studies and analyses to develop system-level diagnostic requirements. These

system-level requirements can then be allocated down to detailed diagnostic design requirements as the design process develops.

A sample SON statement: The weapons system will have a diagnostic capability that integrates mission, safety, and maintenance needs for diagnostic information and embedded, support equipment, and manual methods for obtaining such information to provide the following diagnostic capabilities.

a. Report to the system operator in an understandable and timely manner any significant degradation of the system's ability to perform mission or safety critical functions.

b. Locate, in a timely manner, faults that have degraded or failed a function to the lowest level component that can be replaced, repaired, reprogrammed, or reconfigured to correct the fault and/or restore the function at each applicable level of maintenance.

c. Provide compatibility between diagnostic resources at all levels of maintenance to minimize duplication of these resources, coordinate the use of non-conflicting test parameters, and share useful diagnostic information between maintenance levels.

d. Provide for data recording and analysis capability that will identify diagnostic software and hardware deficiencies and allow timely correction or modification.

This SON statement should be tailored for a specific program and backed up with parameters in the RCM that makes the statement's requirements verifiable, such as the following.

SON Statement	RCM Parameter
Maintenance levels	Organizational, depot, and deployed
Specified constraints	Maximum turn time and sortie rates
	Manpower, airlift, and basing limitations
	Mission scenario

It is important to note that RCM parameters need not be directed specifically toward diagnostic requirements. Mission-oriented RCM parameters will establish goals or bounds that can be used in tradeoffs and analyses to develop diagnostic requirements. Appendix E, 60.2, contains a listing of common RCM parameters that have a diagnostic impact. When SON wording and RCM parameters leave uncertainties (such as what is a clear and timely manner in a above), sufficient detail should be provided in later documents, such as the System Operational Requirements Document (SORD) or Request For Proposal (RFP).

For major systems, the development of a SON is followed by the preparation of a Mission Need Statement (MNS) as required by DoD Instruction 5000.2. The above guidance, relating to diagnostic requirements, also applies to the preparation of the MNS.

Logistic guidance used in the preparation of these documents is contained in AFP-57-9, Defining Logistics Requirements in SONs.

4.1.1.1 Diagnostic inputs to the Statement of Operational Need. Verify that appropriate diagnostic inputs are included by inspecting the SON/RCM and MNS.

APPENDIX A

Verification Guidance

Verification is achieved by inspecting inputs to the SON. This inspection should be the responsibility of HQ AFSC or HQ AFLC, whichever is designated the likely implementing command. Appendix E, 60.0, has guidance on proper RCM parameters. Guidance on SON and RCM preparation is in AFR 57-1.

3.1.1.2 Diagnostic inputs to the Program Management Directive. Diagnostic inputs to the Program Management Directive (PMD) must be provided to ensure that adequate attention is paid to diagnostics by the acquisition agency.

Requirement Rationale

The PMD assigns an Air Force organization to initiate a program (e. g., weapon system development) by issuing a Form 56. Proper attention to the development of a system's diagnostic capability is essential.

Requirement Guidance

The PMD implements the SON for a specific weapon system or equipment. The Program Summary section of the PMD should reflect this SON, reiterating/supporting those operational needs, including diagnostic considerations. The program management direction section of the PMD should task the development organization (e.g., AFSC) to apply the ID Guidelines (MIL-STD-1814 and AFGS-87256) in the development and deployment of the weapon system or equipment.

Lessons Learned

Failing to include integrated diagnostics in the PMD may lead to the procuring agency not giving proper attention and emphasis to the subject, resulting in a less effective, or more costly, diagnostic capability.

4.1.1.2 Diagnostic inputs to the Program Management Directive. Verify that appropriate diagnostic tasking is included in the PMD.

Verification Guidance

Verification is achieved by inspecting the PMD. This inspection is conducted by the preparer, HQ USAF.

3.1.2 Concept Exploration Phase

3.1.2.1 Diagnostic segments of the Program Management Plan sections. The approach to satisfying diagnostic requirements must be included in the appropriate sections of the Air Force Program Management Plan (PMP).

Requirement Rationale

The PMP is an Air Force planning document that describes the program and how it will be conducted. In particular, funding to support the topics defined in the PMP will be identified. It is important that diagnostic issues receive this early, front-end management attention.

APPENDIX A

Requirement Guidance

This requirement is achieved by following procedures in the following MIL-STDs, policy and guidance documents.

MIL-STD-499, 5.1, 10.1	Engineering Management
MIL-STD-1388-1, Task 101	Development of an Early Logistic Support Analysis Strategy.
DoDD 5000.53	Manpower, Personnel, Training, and Safety (MPTS) in the Defense System Acquisition Process
AFSC P 800-3, atch. 3, 4	A Guide for Program Management
AFR-800-8, atch. 5	ILS Program
AFSC/AFLCR 800-23, 4	Policy for Modular Automatic Test Equipment
AFLC/AFSCP 800-34, 7	Acquisition Logistic Management
AFR 800-2, atch. 3	Instructions for Developing and Preparing PMP
AFR 80-14	Test and Evaluation
AFR 800-12	Acquisition of Support Equipment

Requirement Lessons Learned

When the diagnostic pieces are omitted in the planning documents, they will usually be omitted in the budget and in the Statement of Work (SOW) specification of diagnostic tasks that must be performed by the contractor(s).

4.1.2.1 Diagnostic segments of the Program Management Plan sections. Verify that the diagnostic pieces have been incorporated by inspecting the PMP.

Verification Guidance

Use documents referenced in 3.1.2.1.

3.1.2.1.a Modification planning. Include the approach to satisfying diagnostic requirements in modification plans.

Requirement Rationale

Prime systems and equipment being modified may also require modifications to their diagnostic capabilities.

Requirement Guidance

System and equipment modification plans, Classes III, IV, and V, are documented in a Time Compliance Technical Order (TCTO), in accordance with AFR 57-4, Modification Approval and Management. Pay attention to the following when preparing this document.

Adequacy of the present daignostic mix at each maintenance level

Possible diagnostic hardware and software changes based on prime equipment modifications and their integration (e.g., vertical test compatibility)

Test and evaluation of the entire diagnostic capability relating to the prime equipment modifications

Fielding of modified diagnostic capability concurrently with modified prime equipment

Requirement Lessons Learned

The diagnostic implications of system and equipment modifications can adversely impact performance, cost, and schedule if not managed properly.

4.1.2.1.a Modification planning. Verify by inspection that diagnostic implications have been addressed in the TCTO.

Verification Guidance

Use AFR 57-4.

3.1.2.2 Diagnostic segments of the Request For Proposal. The sections of the Request For Proposal (RFP) that address diagnostic issues shall be prepared.

Requirement Rationale

To ensure that diagnostics receive appropriate emphasis in the system engineering activities of the Concept Exploration Phase, the requirements must be placed in contractual documents. With the SOW and other applicable RFP provisions, potential contractors are able to scope, plan, formalize, and price the required diagnostic activities.

Requirement Guidance

The following sections of the RFP should include diagnostic requirements: Special Contract Requirements (Section H), Instructions to Offerors (Section L) and Evaluation Factors for Award (Section M), the SOW, specifications, and the CDRL. Preparation of the RFP diagnostic sections requires coordination with design, engineering, and logistic activities to ensure that there are no gaps, overlaps, or conflicts in requirements. Guidance for preparing a SOW is included in Military Handbook 245.

Special Contract Requirements

Usually, the Special Contract Requirements section of the RFP will require the preparation of a System Engineering Master Schedule (SEMS) to be submitted in response to the RFP. It is evaluated/negotiated during source selection and subsequently becomes part of the contract. The SEMS consists of a series of selected events or milestones identifying the key engineering tasks for each selected event and the success criteria for each key engineering task. It is a schedule tied to specific development event/milestone, rather than to time. Key tasks necessary to be completed for each event must be identified and measurable/verifiable criteria for task completion must be defined. For each task, criteria must be established that defines successful completion of the task. The criteria should be measurable and verifiable. Also, the SEMS can be used to provide a basis for incentives tied to technical accomplishments. The SEMS should be compatible with the System Engineering Master Plan and is the basis for derivation of all subsequent detail planning. Supporting plans are derived from the SEMS. Thus, important integrated diagnostics milestones, the tasks that must be accomplished to achieve them, and the criteria used to verify completion of the tasks must be addressed. Examples of the type of information that should appear in the Concept Exploration SEMS are described below.

a. SOW Task: System alternatives analysis/tradeoffs

Demonstration Milestone: Analyses and tradeoffs of various diagnostic alternatives completed

Technical Tasks: Diagnostic allocation at system level and initial feasibility and risk analyses

Decision Criteria: See 4.1.2.4

b. SOW Task: System alternatives selection

Demonstration Milestone: System Requirements Review (SRR)

Technical Tasks: Initial diagnostic capability definition and SORD, DSRD, and specification diagnostic input

Decision Criteria: See 4.1.2.6

Instructions to Offerors

The Instructions to Offerors section of the RFP contains instructions on proposal preparation. Emphasis should be placed on introducing the concept of ID. Although no standard format exists for this section of the RFP, this section should address the need for managerial and technical information to meet diagnostic requirements. For systems entering development after September 1988, the OSD CALS policy of 5 August 1988 requires specific schedule and cost proposals for integration of contractor technical information systems and processes in acquisition plans, solicitations, and related documents. Emphasize that the contractor will be judged on how well this integration is planned. Refer to the Air Force CALS Application Guide for required implementation activities and recommended contractual language.

Evaluation Factors for Award

The Evaluation Factors for Award, Section M, should clearly indicate that ID and diagnostic requirements will have a significant impact on contractor selection. The evaluation factors should reflect the diagnostic content of the Instructions to Offerors (Section L) from both technical and management points of view. Stress the fact that integrated diagnostics is part of the system engineering process. Ensure that the contractor understands that ID should have interfaces with reliability, maintainability, testability, human engineering, safety, training, and technical information requirements. Discuss the ability to use advanced technology in addressing diagnostic issues. Emphasize the need to designate a single person who will have the authority and responsibility for the entire diagnostic capability. This person should be the same one responsible for the performance capability of the weapon system.

SOW

The SOW presents tasks to be performed by the contractor during the development program. The following is a sample SOW for the Concept Exploration Phase, which should be tailored before applying to a specific program. The tailoring process may include requirements for the contractor to perform specific activities as presented in the ID Roadmap and, as deemed appropriate, to apply the necessary emphasis for ID engineering, design, analysis, development, test and evaluation, and documentation.

APPENDIX A

Sample Concept Exploration Phase SOW

Diagnostic Approach

The contractor shall define the diagnostic approach provided for the maintenance of each system alternative. In accomplishing this definition, the contractor shall establish overall diagnostic design objectives, goals, thresholds, and constraints that support mission requirements and operational constraints in support of the system engineering process of MIL-STD-499 and the logistic support analysis process of MIL-STD-1388-1. The following are critical in this definition.

a. Translate weapon system mission and performance requirements into diagnostic requirements that support the mission scenario.

b. Establish requirements that allow for diagnostic growth as design proceeds through the weapon system acquisition phases.

c. Identify diagnostics-related constraints driven by operational constraints of the system.

d. Identify technology advancements that can be exploited in system development and diagnostic element development and that can increase diagnostic effectiveness; reduce requirements for maintenance; reduce test equipment, technical publications and manpower and skill-level requirements; reduce diagnostic costs; or enhance system availability.

e. Identify existing and planned diagnostic resources that have potential benefits (e.g., family of testers, TIDSs). Identification of resource limitations.

f. Identify existing diagnostic problems on similar systems that should be avoided.

The contractor shall define what constitutes a system failure and shall establish deferred maintenance, performance monitoring, embedded diagnostic, and external diagnostic objectives for the new system at the system and subsystem levels. The contractor shall identify the risks and uncertainties involved in achieving these objectives .

The contractor shall establish BIT, test equipment, technical information, and maintenance manpower and skill-level constraints for the new system for inclusion in system specifications or in other requirements documents. These constraints shall be both quantitative and qualitative constraints.

The contractor shall evaluate alternative diagnostic concepts to include varying degrees of BIT, manual and automatic testing, technical information format and delivery systems, and personnel and training along with deferred, preventive, and scheduled maintenance concepts. The contractor shall identify the selected concept. The evaluation shall include the following.

a. The sensitivity of system mission performance, readiness and safety parameters to variations in key diagnostic element parameters

b. The sensitivity of life cycle costs to variations in diagnostic element parameters

c. The manpower and personnel implications of alternative diagnostic concepts in terms of direct maintenance manhours per operating hour, job classification, skill levels, and experience required at each level of maintenance

d. An estimation of the risk associated with each concept

Diagnostic Specification Development

The contractor shall develop specification requirements that shall allocate diagnostic requirements to applicable design levels. These specifications should address fault detection/isolation, repair verification, performance and condition monitoring, and damage assessment as needed to enable the weapon system to meet operational needs. Diagnostic requirement development and tailoring, for input to specification development, is addressed in Appendix B of this standard and in AFGS-87256.

Integrated Diagnostics Program Plan (IDPP)

The contractor shall develop an IDPP in the format shown in Appendix C. The plan describes the time phasing of each task included in the contractual requirements and its relationship to other tasks. Diagnostic issues that relate to reliability, maintainability, logistics, human engineering, safety, diagnostic maturation, etc., should be addressed in each of these individual program plans.

Diagnostic Program Reviews

As part of the SRR, the contractor shall conduct a review of the diagnostics approach in relation to the above requirements; conduct and document diagnostic design reviews with performing activity personnel and with subcontractors and suppliers; coordinate and conduct diagnostic reviews in conjunction with reliability, maintainability, human engineering, and logistic support reviews, whenever possible; and utilize MIL-STD-1521 and program review criteria contained in MIL-STDs 470, 785, 2165, and 1388-1 as guidance.

CDRL recommendations.

The following is a recommended list of data deliverables for inclusion in the CDRL.

1. IDPP: The only deliverable specifically for diagnostics, it may be included as part of other documents, such as the SEMP. (see Appendix C)

2. Current Diagnostic Capability Baseline Analysis Results:

   DI-S-7116 Comparative Analysis Report, MIL-STD 1388-1, Task 203.2

3. Recommended System - Level Diagnostic Performance and Approaches (specification preparation is optional):

   DI-CMAN-80008 System Specification, AFGS-87256, MIL-STD 490 Appen. I
   DI-MCCR-80025 Preliminary Software Requirements Specification, DOD-STD 2167
   DI-T-7199 Testability Analysis Report, MIL-STD 2165 Task 201.2.4

4. Diagnostic Implementation Feasibility/Risk Reduction Proposals:

   DI-T-7199 Testability Analysis Report, MIL-STD 2165, Task 201

5. Documented results of diagnostic assessment as an integral part of System Requirements Review documentation.

DI-A-7088	Conference Agenda, MIL-STD 1521, Appendix A
DI-A-7089	Conference Minutes, MIL-STD 1521, Appendix A

The above DIDs have been identified from the AMSDL as candidates to obtain the information/ data contractually to satisfy the stated deliverables. The candidate DIDs, in most cases, must be tailored to meet the diagnostic requirements.

Data deliverables may be identified by DIDs cited in MIL-STD-2165 or by other programmatic military standards and as tailored by CDRLs.

4.1.2.2 Diagnostic segments of the Request For Proposal. Verify that appropriate diagnostic segments and provisions are in the Concept Exploration RFP, including the SOW, the Evaluation Criteria, and the Instructions to Offerors, by inspecting these documents.

Verification Guidance

The following checklist should be used.

Is there a requirement for a structured methodology to derive diagnostic requirements from weapon system mission and performance requirements?

Does the RFP/SOW relate the importance of integrating diagnostic elements and of meeting diagnostic requirements?

Is there a requirement for establishing the concept of diagnostic growth throughout the acquisition period and the initial deployment?

Does the RFP/SOW reflect the need for a baseline comparison analysis (LSA task 203) and feasibility/risk analysis?

Are all diagnostic elements addressed as an integrated capability as well as individually?

Verification Lessons Learned

Failure to verify the completeness, sufficiency, and correctness of diagnostic inputs to the RFP may lead to inadequate contractor response to diagnostic requirements.

3.1.2.3 Diagnostic segments of program plans. Diagnostic inputs to the various contractor-prepared management plans must be prepared.

Requirement Rationale

One of the initial contractual efforts undertaken after the award of contract is the preparation of planning documents. The integrated diagnostic process must be clearly described in these documents so there is a common understanding between the Government and its contractors on how integrated diagnostics will be accomplished.

Requirement Guidance

The IDPP is a key diagnostic planning document. Appendix C describes the format and content of an IDPP. As an alternative to a separate IDPP, the required diagnostics planning

information may be included in the SEMP and in various other management plans. If this alternative is selected in lieu of the IDPP, the following guidance applies.

The preparation of a SEMP, which is composed of three parts, is based on MIL-STD-499. Specific guidance relating to the preparation of the diagnostic segments of this plan follows.

SEMP PART I -- Technical Program Planning and Control

This part of the plan should describe the contractor(s) organization and internal interfaces required to integrate the design of the diagnostic capability into the system engineering process. Address the extent to which integrated diagnostics has been institutionalized within the contractor's operating policies and procedures. A single individual with the overall responsibility and authority for implementation of the integration process shall be identified. A review process should be described to ensure that the task is integrated across all involved functional disciplines and that an adequate feedback system exists to redirect efforts to meet diagnostic goals and requirements. Where subcontractors, or teaming arrangements with associate contractors, contribute to the integration of the diagnostic capability, describe these organizational interfaces and the planning and control functions to be implemented to ensure a totally integrated effort. A schedule must be established for each of the tasks cited in the SOW.

SEMP PART II -- System Engineering Process

This part of the plan should contain a description of the process to be used in meeting the overall program objectives and requirements, the general maintenance concept to be used to support the system/equipment, and the contractor's methodology for arriving at the desired diagnostic approach. Analysis and trade studies should be identified and the proposed methodology for conducting these studies described. Reference to models approved by the procuring activity may satisfy the methodology requirement. If not, these models or methodologies should be described, along with their capabilities and limitations. The relationship and interface with the LSAs required by MIL-STD-1388-1 should be established.

SEMP PART III -- Engineering Specialty Integration

During the Concept Exploration Phase, two major plans must be integrated with the SEMP: the LSA Plan (LSAP) and the Integrated Support PLan (ISP). Other engineering specialty functions and requirements are reflected in these plans. Thus, the SEMP must allow the LSAP and ISP, along with their diagnostic contents, to be integrated with the system engineering function.

4.1.2.3 Diagnostic segments of program plans. Verify that the integrated diagnostic process has been included in the SEMP, the LSAP, the ISP, or the IDPP by inspecting these documents.

Verification Rationale

Inspection is the only feasible verification method.

Verification Guidance

Examine the SEMP, LSAP, ISP or the IDPP to see if they met the following.

1. Provide a vehicle for identifying the contractors' roles and responsibilities, thereby helping direct and control the work of the program.

2. Show how the parts fit together, providing a basis for coordinating related activities.

3. Provide a baseline for any change of scope.

4. Help everyone determine when the objectives have been reached and, therefore, when the effort is complete.

The main evaluation factor is whether the SEMP, LSAP, and ISP demonstrate that ID is truly an integral part of the system engineering process.

Verification Lessons Learned

Front-end analysis is key to the proper implementation of integrated diagnostics. The lack of proper front-end analysis will result in a fragmented design and development, without a proper mix of diagnostic elements.

3.1.2.3.1 Data Sharing Plans. The contractor shall establish and implement formal data sharing plans to ensure that functional organizations, team members, and subcontractors have access to current diagnostic development information throughout the concept exploration phase.

Requirement Rationale

Much of the technical data necessary to develop ID effectively in a system already exists within a contractor's facility. Some of this information, however, is not available to each group, subcontractor, or team member involved with the development. This information is either not distributed to the organizations using it or is distributed too late to be of any practical use. Contractors that are involved in the defense business are typically subdivided into functional organizations with specific areas of responsibilities or they subcontract out these responsibilities. These discrete organizations or subcontractors/team members may have an important part to play in developing high quality diagnostics. An effective means must be established to allow communication of iterative information between groups, contractors and team members as the design concept progresses. Merely communicating necessary information within the company or to other participating contractors is not sufficient, however, unless it is done early and frequently in the development process. Otherwise, it becomes a documentation task rather than a sharing of information for the purpose of influencing the design.

Requirement Guidance

The acquisition agency should instruct the contractor to define a formal data sharing plan (it can be part of the system engineering management plan or the IDPP). The plan should address the sharing of information used in the design of the weapon system. Appendix F gives examples of the type of data elements and information that are required to perform diagnostic design activities during Concept Exploration (data elements listed in Appendix F matrices and that apply to the Concept Exploration Phase are those that have paragraph references beginning with 3.1). The plan should also address the interface with information regarding the performance of the diagnostic activity as it proceeds through demonstration, test and evaluation, and maturation. The plan should describe (1) the types of information that will be addressed, (2) the sources of this information, (3) the method for sharing this information among the various organizations involved in the design of the diagnostic capability, and (4) the method and frequency of updating the information contained in the data bank.

APPENDIX A

Acquisition managers who have responsibility for preparing contract requirements addressing digital delivery or access to weapon system technical information and functional requirements for integration of contractor processes that create and use technical information should refer to MIL-HDBK-59, Department of Defense Computer-Aided Acquisition and Logistic Support Program Implementation Guide. This handbook provides the following.

A description of the integrated, shared data environment toward which Computer Aided Acquisition and Logistics (CALS) is targeted and guidance on the contractor proposals and plans for creating and using such an environment as required by the government

Guidance on the acquisition of digital data for technical manuals; technical data packages, including engineering drawings, specifications, and book-form drawings; logistic support analysis record data; and training materials

Guidance on requesting contractor proposals to improve weapon system reliability and maintainability through integration of R&M computer-aided design and engineering

A formal data sharing plan should specify both the data elements expected to be shared and the functional organizations and participating contractors/team members that need to interact on diagnostic design. Any integration of the data structure, such as neutral interface formats (e.g., IGES, EDIF, SGML, VHDL) that design systems support, should be discussed. Any ability to interface design data with MIL-STD-1388-2 (LSAR) data should be discussed. The contractor should disclose the ability to deliver digital data to the government in government supported, standard formats in such areas as technical data, training materials, analytical models and analyses, software, operating manuals, support equipment data, LSAR data, etc. Any ability for tools within the contractors, team members, and vendor's CAE system to share data should be identified. Establishing lessons learned libraries should also be addressed.

During the concept exploration phase, historical diagnostic implementation characteristics are needed as a lessons learned tool. Results of design tradeoff studies, statements of constraints on diagnostic budget in terms of real estate or response time, the criteria for determining whether the diagnostics requirement is satisfied, and incremental design descriptions are also necessary entries into an information system. Information system aids that facilitate the integration of R&M into the design process should be included.

It is essential to have frequent incremental releases of the most current information so that functional organizations can assess the impact to integrated diagnostics based upon the current changes in system design. If there will be subcontractors or a teaming among companies on a contract, then data sharing among vendors (including GFE equipment) and team members must be planned and implemented among all involved in the design, fabrication, deployment, and support of the weapon system for communication of diagnostic information. Standardization of tracking systems should be established early in the program, which would also include all providing repair services (i.e., vendors, depots). The technical databases must include provisions for describing, listing, and sorting on the electronically generated fault list information that resides in memory-capable equipments. Provisions to sort this information on other parameters, such as work unit code, must also be detailed.

Subcontractors or team members must also make available to the contractor how a specific component may fail, what the actual symptoms of a failure are, the different failure modes, and the relationship of one to another. Vendors or team members should provide the internal functions/model of all application specific integrated circuits, programmable devices, and hybrids. The company/organization doing the repair will also need this type of information about the unit under test (UUT). In less complex units under test, an equivalent manual form

of the information should be addressed. The contractor must also make available to the subcontractors input regarding the weapon system built-in-test (BIT), built-in-test equipment (BITE), and potential failure symptoms of all the specific modules that the aircrew members can identify so that the diagnostic information can be formatted to support a symptom-based diagnostic approach.

Depending on the contractor's organizational structure and size, the data sharing plan may be difficult to implement without automation. Automation of the data sharing plan should follow CALS Standards and Application Guidance documents to provide assistance for the contractor to integrate the data systems and provide interface to the acquisition authority. These documents are as follows.

MIL-STD-1840A, "Automated Interchange of Technical Information" - provides rules for organizing files of digital data into a complete deliverable document using the supporting CALS military specifications.

MIL-D-28000, "Digital Representation for Communication of Product Data: IGES Application Subsets" - defines a series of application-specific subsets of the Initial Graphics Exchange Specification (IGES).

MIL-M-28001, "Markup Requirement and Generic Style Specification for Electronic Printed Output and Exchange of Text" - defines standard DoD requirements for automated publishing of page-oriented technical manuals and technical orders. It also defines a common DoD-wide implementation of International Standard ISO 8879 as well as defining typographic tags and format rules for document composition.

MIL-R-28002, "Requirements for Raster Graphics Representation in Binary Format" - defines engineering drawing and technical manual illustrations requirements for raster graphics compressed in accordance with International Standard CCITT T.6, "Facsimile Coding Schemes and Coding Control Functions for Group 4 Facsimile Apparatus", and FED-STD-1065.

MIL-D-28003, "Digital Representation for Communication of Illustration Data: CGM Application Profile" - defines an application profile for delivery of technical manual illustrations using the Computer Graphics Metafile (CGM).

The contractor is free to construct and tailor the data sharing system. MIL-STD should not inhibit the contractor's ability to be innovative.

Requirement Lessons Learned

Standard maintainability and reliability data is insufficient for proper integration of diagnostics by the design team. Descriptions of specific tests failed are required, in addition to the codes, such as "how mal" currently collected. The developers of test equipment for the different levels of maintenance must be able to communicate tolerance requirements and other pertinent design parameters throughout the development process to prevent "built in" test discrepancies.

Contractors are beginning to automate their design process but most do not have established methods for sharing information between in-house organizations, team members, or subcontractors on an iterative basis. Most share data after a particular work area has completed its job. Often, this is too late to influence the work of other functional areas, and, as a result, the diagnostics are not integrated.

4.1.2.3.1 Data Sharing Plans. The formal data sharing plan and implementation shall be verified by inspection.

Verification Rationale

The contractor is being required to formally document and implement the plan for sharing diagnostic information within his organization, among team members, and subcontractors (vendors). The acquisition agency must be able to review the plan and examine actual implementation of the procedures. This examination can best be accomplished by inspection.

Verification Guidance

The following checklist should be used.

1. Does the data sharing plan address the establishment of a common database for diagnostics, which includes data elements generated from various "ility" functions (reliability, maintainability, testability, human engineering, safety, logistics)? Does it tie this database to diagnostic design activities?

2. Does the data sharing plan define the timing of incremental releases of the most current design information in order for functional organizations to assess the impact of the changes to integrated diagnostics?

3. Does the common database have access to historical diagnostic capability performance data from similar systems and equipments?

4. Does the plan address the interaction between DoD, contractor, and subcontractor data systems?

5. Is the interface with the DoD CALS program defined?

3.1.2.4 Diagnostic requirements derivation and allocation. Diagnostic requirements and initial diagnostic approaches based on weapon system needs shall be defined.

Requirement Rationale

The definition of diagnostic requirements and alternative approaches to meeting those requirements must be established early in the weapon system life cycle to introduce diagnostic considerations into the initial design concepts and to maximize life cycle cost savings and weapon system supportability. Initial design decisions made in this phase may improperly restrain diagnostic design options if diagnostic requirements are not adequately considered.

Requirement Guidance

Analyses should be performed early in the weapon system life cycle to define diagnostic requirements at the system level, usually down to the segment and element levels, and to develop initial diagnostic approach alternatives for each alternative weapon system configuration.

These analyses should address system design alternatives for the Dem/Val Phase of the program. A preliminary diagnostic concept is generated from analysis and trades of alternative diagnostic capabilities. Diagnostic capability profiles are derived from analysis of the impact of prioritized weapon system characteristics on the diagnostic elements. Optimized diagnostic

concepts and goals are generated for each alternative weapon system configuration, based on preliminary diagnostic capability profiles. The results of these tradeoffs are essential for the collation activity of the diagnostic allocation process described in Appendix B. General guidance is provided in MIL-STD-499. A generic methodology for deriving diagnostic requirements is contained in Appendix B.

Specifically, this requirement can be satisfied through a structured, analytical process based on the generic methodology contained in Appendix B, in conjunction with a multitude of task descriptions and guidance contained in other programmatic MIL-STDs and MIL-SPECs. Of particular applicability is Task 201 of MIL-STD-2165, which addresses establishing testability requirements. Several other MIL-STDs and MIL-SPECs that have a direct interface with deriving diagnostic requirements are listed below, with their specific interfaces contained in 20.5 of Appendix B.

MIL-STD-470	Maintainability Program for System and Equipment
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-882	System Safety Program Requirements
MIL-STD-1388-1	Logistic Support Analysis
MIL-H-46855	Engineering Requirements for Military Systems, Equipment, and Facilities.

Deriving diagnostic requirements. Diagnostic requirements should be derived from operational needs and allocated systematically to ensure diagnostic requirements and any associated accuracies support the weapon systems mission needs within operational constraints. Applying guidance from Appendix B, the following activities (steps) should be taken.

a. Translate operational needs. In the Concept Exploration Phase, translation is a critical activity because this should be the initial effort to identify the role diagnostics must play in allowing the weapon system to perform its mission. Proper translation can identify needed diagnostic coverage while avoiding unnecessary reductions in the design flexibility that exists in this phase. A typical source of operational needs in this phase would be the program SON, PSOC, or RFP. Identify those operational needs that will drive the diagnostic requirements and isolate applicable diagnostic needs as discussed in Appendix B.

b. Collate the diagnostic needs into diagnostic requirements. Using the generic diagnostic requirements from AFGS-87256, create a set of diagnostic requirements that covers the diagnostic needs from a above and any additional needs for diagnostic information from design decisions made in this phase. Ensure complete coverage of the design levels being addressed in the Concept Exploration Phase and include any other diagnostic requirements that may be known about design levels not yet addressed.

Allocating diagnostic requirements. Allocation of diagnostic requirements in the Concept Exploration Phase is important because the initial implementation steps made in this phase are critical. There should be some assignments of resources to accomplish those requirements applicable to the design levels being addressed, typically the system, segment, and element levels. These resource assignments are the first steps in implemention that establish the initial diagnostic mix that will influence, but not dominate, decisions on implementing diagnostic requirements in the follow-on phases. These initial implementations should also create a need to pass down requirements for supporting diagnostic information from many subfunctions, as few requirements can be fully met in this phase. There also should be some diagnostic requirements that concern functions at design levels yet to be addressed, such as validation of

depot repair of all SRUs. These requirements should be acknowledged now but passed down to lower design levels, assembly or component in this case, for implementation.

Requirement Lessons Learned

Diagnostics (including testability) is a distinct characteristic of design. Deferral of diagnostic efforts to the Dem/Val or FSD Phases has resulted in expensive logistic support work-arounds to achieve requirements during deployment.

4.1.2.4 Diagnostic requirements derivation and allocation. Verify by checklist evaluation that the weapon system diagnostic requirements and diagnostic approaches for entering Dem/Val are based upon weapon system needs.

Verification Rationale

The most effective method to determine that the required analyses, tradeoffs, and tasks were performed is to use a checklist to identify activity that must be performed as part of this verification.

Verification Guidance

The following checklist can be used to verify that the prime system analyses and tradeoff studies consider all of the diagnostic elements to the level appropriate for the Concept Exploration Phase.

1. Were diagnostic requirements derived from mission, maintenance, and safety needs and traceable back to these needs?

2. Were technical evaluations and studies conducted to determine the optimized goals of the diagnostic element preliminary design concept?

3. Was logistic support considered in the technical evaluation and tradeoffs?

4. Was the feasibility of producing the embedded diagnostic elements considered?

5. Was the impact of the diagnostic element's preliminary design concept on LCC determined through LCC analyses and trades?

6. Were all of the following diagnostic elements addressed in the above checklist?

    Embedded Diagnostics

    System Level
    - System Integrated Test (SIT)
    - Design for Testability (includes BIT)
    - Online status monitoring

    Element Level
    - Design for Testability (includes BIT)
    - Diagnostic interfaces

    External Diagnostics

Offline test equipment compatibility with maintenance concept
Impact on technical data requirements
Impact on manpower and skill-level requirements
Impact on training requirements
Diagnostic data collection requirements

3.1.2.5 Diagnostic inputs to the Test and Evaluation Master Plan. Diagnostic inputs shall be incorporated into the Test and Evaluation Master Plan (TEMP).

Requirement Rationale

Test and evaluation is an essential part of the diagnostic capability maturation process. Therefore, diagnostic issues should be addressed in the TEMP.

Requirement Guidance

DoD Directive 5000.3 is the policy document that requires the preparation of a TEMP. This directive is amplified by AFR-80-14, Research and Development Test and Evaluation. The TEMP is the basic planning document for all test and evaluation for a particular acquisition. During Concept Exploration, test and evaluation issues play a significant role in the selection of the preferred diagnostic alternatives, since the test and evaluation of the diagnostic capability is a significant problem. Emphasis should be placed on diagnostic aspects of high-risk development efforts that will be conducted during the subsequent acquisition phases.

DoD 5000.3-M-1 contains the guidelines for preparing a TEMP. Chapter 2 contains the format for the TEMP, in which Part III relates to DT&E and Part IV deals with OT&E. Each of these parts deals with a significant number of diagnostic issues, such as reliability, maintainability, logistics, safety, software, and training. Care should be exercised, especially at OT&E (both interim and follow-on), to ensure that the entire diagnostic capability will be evaluated.

Requirement Lessons Learned

One of the major lessons learned in the acquisition of presently deployed aircraft is that test and evaluation of the entire diagnostic capability must be undertaken at OT&E. The initiation of the TEMP during the early phases of the weapon system acquisition ensures that the contractor and the Air Force will understand that test and evaluation of diagnostic capability will be an important factor. Thus, attention will be given to the timely development of the entire diagnostic capability.

4.1.2.5 Diagnostic inputs to the Test and Evaluation Master Plan . Verify that adequate diagnostic inputs have been made to the TEMP.

Verification Rationale

Inspection of this plan is the only practical method available for verification.

Verification Guidance

Use DoD Directive 5000.3-M-1 and the following checklist to verify the adequacy of the TEMP.

1. Have diagnostic-related inputs to the TEMP been included?

2. Have diagnostic aspects of high-risk items been given special consideration?

3. Has emphasis been placed on evaluation of the entire diagnostic capability?

4. Is there a logical relationship between the TEMP and the diagnostic maturation program plan?

Verification Lessons Learned

Without proper verification of the TEMP, diagnostic tests and evaluation may not occur in a timely and effective fashion.

3.1.2.6 Diagnostic capability during System Requirements Review. A review of diagnostic requirements and the analysis that lead to the selection of the preferred diagnostic approach shall be included during the System Requirements Review (SRR).

Requirement Guidance

The diagnostic portion of the SRR should be conducted with MIL-STD-1521, Appendix A, as a guide. The diagnostic review should analyze the system items that are related to diagnostics. The following items should be reviewed, as appropriate.

Mission and Requirements Analysis
Functional Flow Analysis
Preliminary Requirements Allocation
System/Cost Effectiveness Analysis
Trade Studies
Synthesis
Logistic Support Analysis
Specialty Discipline Studies
Specification Generation
Program Risk Analysis
Integrated Test Planning
Technical Performance Measurement
Engineering Integration
System Safety
Human Factors Analysis
Life Cycle Cost Analysis
Manpower Requirements/Personnel Analysis
Milestone Schedules

The diagnostic review should also address the impact of the items listed above on the diagnostic pieces listed below.

Designed-in Reliability, Prognostics, and Testability
Self-Test, Built-In Test, System Integrated Test
Support Equipment, TIDS
Technical Data
Personnel Skill Requirements
Training and Training Devices

Requirement Lessons Learned

Lack of front-end attention to designing diagnostic capability can lead to inadequate weapon system readiness, excessive LCC, and wasted manpower.

4.1.2.6 Diagnostic capability during System Requirements Review. Verify by analysis that proper methods are used to ensure that the diagnostic segment of the SRR will correctly evaluate the preliminary diagnostic concept of the emerging system/equipment.

APPENDIX A

Verification Rationale

Analyses are the most effective verification method during an SRR and are in accordance with MIL-STD-1521 procedures.

Verification Guidance

MIL-STD-1521, Appendix A, provides procedures and guidance for the SRR. The procedures and listed items must be reviewed from a diagnostic perspective. The following checklist may be helpful.

1. Does the contractor have a corporate policy identifying procedures for internal reviews as well as customer required reviews?

2. Is emphasis being placed on technical interchange meetings between contractor and customer rather than large-scale reviews?

3. Are qualified diagnostic technical experts, who can challenge the design and access risks, included in these reviews?

4. Are diagnostic reviews held as an integral part of the Prime System Review?

Verification Lessons Learned

Reviews must be conducted as a "single" review, not a number of separate reviews conducted in parallel (e. g., logistics, maintainability, prime system). Integrated diagnostics, being part of the system engineering process, must be an integral part of the prime system review SRR.

3.1.2.7 Diagnostic specifications. Diagnostic requirements resulting from the preliminary diagnostic analysis and optimization tasks shall be incorporated into the system specification or equivalent requirement documents.

Requirement Rationale

Continuation of the diagnostic capability acquisition into the Dem/Val or FSD depends on establishing requirements that can be incorporated into the solicitations, proposals and contracts for those phases.

Requirement Guidance

Tailorable diagnostic requirements for input to specifications are contained in AFGS-87256, 3.1 and 3.2.

4.1.2.7 Diagnostic specifications. Verify that diagnostic inputs have been made to the system specification or equivalent requirement documents by inspecting these documents.

Verification Rationale

Inspection is an effective way to verify that diagnostic requirements have been entered into the required documents.

APPENDIX A

Verification Guidance

See AFGS-87256, 4.1 and 4.2 for verification of specific diagnostic requirements that lead to the creation of diagnostic related specifications.

3.1.2.8 Diagnostic inputs to the System Operational Requirements Document. Diagnostic inputs to the System Operational Requirements Document (SORD) must be provided to establish the basis for developing and tracking the diagnostic capability.

Requirement Rationale

The SORD is the requirements and planning document that addresses operational and support needs. It amplifies and refines the SON. The SORD and its attached Requirements Correlation Matrix (RCM) document and track the goals and requirements that influence the design of the diagnostic capability.

Requirement Guidance

Use AFR-57-1, Operational Needs, Requirements, and Concepts, as a guide. An RCM is attached to the SORD. Formats for both the SORD and the RCM are included in AFR-57-1. The RCM lists parameters and requirements that the system must have to accomplish its intended mission, and is used to document and track the formulation of and changes to these user requirements as they evolve through the program acquisition process.

Attachment 6 to AFR-57-1 provides the format for the SORD. The content of the SORD evolves with the design of the weapon system. The SORD is prepared by the using command early in the Concept Exploration Phase and must be approved prior to Milestone I. Inputs relative to the system's diagnostic capability should be reflected throughout the SORD. Particular attention should be paid to the following two paragraphs in the SORD format.

Combat or Mission Reliability and Maintainability (IV.A.1.b). This paragraph recognizes the need for different performance capabilities based on mission profiles and environmental conditions, which are critical to accomplish each mission requirement. This is one of the major requirements that influence the design of the diagnostic capability. In addition, this paragraph should further amplify the SON statements concerning the diagnostic capability and how these requirements are reflected in the RCM, such as the following.

SON Statement	RCM Parameter
Inflight monitoring	Failure latency
Fault isolation	Fix rate
Vertical testability	CNDs, RTOKs

Logistics Reliability and Maintainability (IV.A.1.c). This paragraph should amplify the SON statement for a diagnostic data recording and analysis capability by citing quantitative efficiency and effectiveness measures for the capability (e.g., cost, time, accuracy).

Select SORD diagnostic wording with two concerns. First, provide the general concepts and needs that will be expanded or clarified by the RCM parameters. Second, avoid specifying diagnostic-only requirements before trades or analyses have been made to determine values that best support operational needs. Such SORD statements may be limited to highlighting the major needs for diagnostic coverage and putting limits on diagnostic accuracy based on top-level program metrics. These statements should lead to analyses during the upcoming phase

that isolate specific requirements and accuracy metrics for diagnostics. The following are examples of such SORD statements.

The system level

> The diagnostic capability to detect, isolate, and report faults needed to support mission, maintenance, and safety decisions of the (w/s name) shall be provided using an integrated combination of all available diagnostic resources, with an accuracy that, in conjunction with other relevant factors, permits accomplishing the mission within program constraints.

The segment level

> The diagnostic capability to detect and report faulty mission critical functions to support mission decisions shall be provided with an accuracy that permits, along with other relevant factors, a mission completion success probability of at least __.
>
> The diagnostic capability to detect and report faulty safety critical functions to support safety decisions shall be provided with an accuracy that precludes, along with other relevant factors, exceeding an accident rate of not greater than __.
>
> The diagnostic capability to detect and report faulty system functions to support maintenance decisions shall be provided with an accuracy that permits, along with other relevant factors, a ratio of maintenance man hours per flying hour of not greater than __.

Appendix E, 60.2 lists operational parameters along with their diagnostic impact. This appendix section should aid in tailoring the above sample SORD statements or in creating other diagnostic statements applicable to a given situation. Statements more specific than the above may be used if the design has progressed to a detailed level. Use the requirements derivation and allocation process in Appendix B and AFGS-87256 to generate more specific diagnostic requirements.

The format for the RCM is contained in Attachment 8 to AFR-57-1. The RCM contains both requirements and goals, which become requirements as the design of the weapon system progresses. The RCM documents the growth of diagnostic measures as the system proceeds through the development process. By carefully selecting operational and support parameters for the RCM it should be possible to ensure that the final diagnostic capability meets these parameters without constraining contractor innovation. Appendix E, 60.2 may also be used to relate RCM parameters to their diagnostic impact.

Requirement Lessons Learned

Ignoring diagnostics in the SORD can lead to unsatisfactory diagnostic capability. However, specifying diagnostic-only requirements in early program documents has not been an effective alternative (e.g., 95 percent FD/FI has proven difficult for design and verification). Diagnostic requirements are usually only one facet of a higher operational or support requirement (e.g., fault isolation is actually a component of requirements for mission capable rates, utilization rates, man hours per flying hour, etc.). By specifying proper operational and support parameters in the SORD and RCM and by ensuring that contractors use these parameters in a system engineering approach, the resultant diagnostic capability will support the major requirements without unnecessarily constraining contractors.

4.1.2.8 Diagnostic inputs to the System Operational Requirements Document. Verify that appropriate diagnostic inputs are included by inspecting the SORD and the RCM.

Verification Rationale

Inspection is the most effective verification method, as guidance is included in AFR-57-1 and the following checklist .

Verification Guidance

Inspection of inputs to the SORD/RCM should be the responsibility of the implementing command. Guidance in AFR-57-1 should be followed in addition to the following checklist.

1. Are the proper operational and support parameters specified, to drive development of diagnostic requirements? See Appendix E, 60.2

2. Are any diagnostic-only requirements based on mission needs and operational constraints and are they verifiable?

3. Are diagnostic issues, goals, and requirements reflected throughout the SORD for all elements that make up the diagnostic capability?

4. Have provisions for diagnostic growth been included?

Verification Lessons Learned

Establishment of inadequate or inappropriate diagnostic requirements often result in an inadequate or unverifiable diagnostic capability.

3.1.2.9 Diagnostic inputs to the Depot Support Requirement Document. Diagnostic inputs to the Depot Support Requirement Document (DSRD) must be provided to establish the plan and requirements for providing both Depot maintenance and material support.

Requirement Rationale

The DSRD is the planning document for Depot support. It supports the SON and the SORD.

Requirement Guidance

AFR-57-1, Operational Needs, Requirements, and Concepts, should be used as a guide. The DSRD is prepared and issued in parallel with the SORD. Attachment 9 to AFR-57-1 is the format for preparation of the DSRD. The content of the DSRD evolves with the design of the weapon system. The initial version is required at Milestone I. The system's diagnostic capability should be reflected throughout the DSRD for all diagnostic elements used in the depot. Particular attention should be paid to the concept of vertical testability which, at depot level, promises the use of ATE common with other maintenance levels. This topic should be addressed under the MATE section of the DSRD (Section 2d of Attachment 9 to AFR-57-1).

Requirement Lessons Learned

Improper attention paid to early planning for depot support can result in lengthy and costly periods for transitioning from contractor to Air Force support.

4.1.2.9 Diagnostic inputs to the Depot Support Requirement Document. Verify that appropriate diagnostic inputs are included by inspecting the DSRD.

Verification Rationale

Inspection is as the most effective verification method since guidance is provided in AFR-57-1 and the following checklist.

Verification Guidance

Verification is achieved by inspection and analysis of inputs to the DSRD. This verification should be the responsibility of the implementing command. Guidance in AFR-57-1 should be followed. In addition, the following checklist should be used.

1. Have vertical testability requirements been incorporated?.

2. Have the diagnostic elements that compose the diagnostic capability been integrated?

3.1.2.10 Diagnostic inputs to System Concept Paper. Diagnostic inputs must be included in the System Concept Paper (SCP).

Requirement Rationale

The SCP is used to summarize the result of the Concept Exploration Phase, to describe the weapon system acquisition strategy, to identify concepts for the Dem/Val Phase, to state reasons for eliminating alternative systems, and to establish goals and thresholds to be met at Milestone II. Diagnostic capability issues that affect the goals and thresholds must be included in the SCP.

Requirement Guidance

See DoD Instruction 5000.2, F3, and enclosure 4 for guidance on SCP contents.

Requirement Lessons Learned

Failure to include diagnostics in the SCP inhibits planning for the diagnostic impact on Dem/Val Phase goals and thresholds. Resulting diagnostic funding constraints and insufficient diagnostic requirements will inhibit the diagnostic effort during Dem/Val Phase.

4.1.2.10 Diagnostic inputs to System Concept Paper. Verify by checklist evaluation that the diagnostic impact on SCP issues, defined in DoD documents, is included in the SCP.

Verification Rationale

Inspection is the most effective verification method as guidance is included in DoD Instruction 5000.2, Enclosure 4, and the following checklist.

Verification Guidance

Inspection of the SCP is conducted by reviewing the guidance in DoD Instruction 5000.2, enclosure 4. In addition, the following checklist should be used.

1. Does SCP adequately address all aspects of the proposed diagnostic capability in relation to weapon system performance, cost, and manpower implications?

2. Has a risk assessment of the diagnostic capability been addressed?

Verification Lessons Learned

Verification of the diagnostic content of the SCP, without inspection by persons with a good understanding of diagnostics, can result in an inferior SCP. With the present emphasis on the need for improved weapon system diagnostics, this could result in delays in approval for proceeding into Dem/Val or even in more drastic consequences.

3.1.3 Demonstration/Validation (Dem/Val) Phase

3.1.3.1 Diagnostic segments of the Program Management Plan. The diagnostic segments of the Program Management Plan (PMP) shall be developed or, if previously initiated, reviewed and updated for consistency with current program direction.

Requirement Rationale

Integrating diagnostic requirements into the Dem/Val Phase PMP enables diagnostics tasks to be properly funded, performance to be reviewed, and parametric values, such as FD/FI levels, to be specified prior to initiating the FSD Phase.

Requirement Guidance

This requirement is composed of a number of subordinate requirements in 3.1.3.1.1 through 3.1.3.1.3.2 below.

For those acquisition programs that have performed a Concept Exploration Phase, this requirement provides for updating the diagnostics-relevant sections of the PMP for the Dem/Val Phase. For those acquisition programs that are initiated at the Dem/Val Phase, this requirement defines the inputs that are required in the diagnostics-relevant section of the PMP.

This requirement is achieved through the application of the procedures stated in the applicable MIL-STDs and Air Force regulations and pamphlets. Documents that are used to accomplish this requirement include the following.

MIL-STD-499, 5.1, 10.1	Engineering Management
MIL-STD-1388-1, Task 101	Development of an Early Logistic Support Analysis Strategy.
AFSC P 800-3, Atch. 3, 4	A Guide for Program Management
AFR 800-8, Atch. 5	ILS Program
AFSC/AFLC R 800-23, 4	Policy for Modular Automatic Test Equipment
AFLC/AFSCP 800-34, Ch. 7	Acquisition Logistics Management
AFR 80-14	Test and Evaluation
AFR 800-2, Atch 3	Instructions for Developing and Preparing PMP
AFR 800-12	Acquisition of Support Equipment

4.1.3.1 Diagnostic segments of the Program Management Plan. Verify by inspection that the diagnostic requirements have been incorporated in the applicable sections of the PMP.

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Inspect the PMP using guidance in documents identified in 3.1.3.1.

3.1.3.1.a Modification planning. Include the approach to satisfying diagnostic requirements in modification plans.

Requirement Rationale

Prime systems and equipment being modified may also require modifications to their diagnostic capabilities.

Requirement Guidance

System and equipment modification plans, Classes III, IV, and V, are documented in a Time Compliance Technical Order (TCTO), in accordance with AFR 57-4, Modification Approval and Management. Pay attention to the following when preparing this document.

Adequacy of the present daignostic mix at each maintenance level

Possible diagnostic hardware and software changes based on prime equipment modifications and their integration (e.g., vertical test compatibility).

Test and evaluation of the entire diagnostic capability relating to the prime equipment modifications.

Fielding of modified diagnostic capability concurrently with modified prime equipment.

Requirement Lessons Learned

The diagnostic implications of system and equipment modifications can adversely impact performance, cost, and schedule if not managed properly.

4.1.3.1.a Modification planning. Verify by inspection that diagnostic implications have been addressed in the TCTO.

Verification Guidance

Use AFR 57-4.

3.1.3.1.1 System engineering and configuration (PMP Section 4). A requirement for diagnostics capability shall be included in the system engineering management approach included in the PMP.

Requirement Rationale

This section of the PMP describes the overall approach to be taken in system engineering. Since the diagnostics process must be integrated into the prime system/equipment system engineering process, it should be included as part of the program effort that is defined in this section of the PMP.

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This section of the PMP requires that the following topics, which have a relationship to the diagnostic capability, be defined from a system engineering management perspective. Included with each identified topic is the diagnostic element relationship.

> Topic 1: Describe the program effort for defining the preferred system configuration (system definition), engineering/technical management, and the integration of engineering and specialty programs.
>
> > Diagnostic Relationship: Include, as appropriate, in the program effort description the identification of both the embedded and external diagnostic elements.
>
> Topic 2: Include summaries of plans for risk reduction programs, technical reviews and studies, and analyses (particularly life cycle cost analyses).
>
> > Diagnostic Relationship: Diagnostic-peculiar tradeoffs (e.g., BIT vs offline ATE) and diagnostic-related portions of tradeoffs and analyses should be included in the summaries or plans.

In the summary of the planned approach for system engineering and engineering management, include the diagnostic relationship, as appropriate, as shown below.

1. Engineering definition of the complete system: Include the diagnostic elements as part of the engineering definition.

2. Reliability, maintainability, human engineering, vulnerability, survivability, value engineering, quality assurance, producibility, and technical performance measurement: Include for each topic the appropriate diagnostic element impact.

3. Computer, computer programs, and associated documentation to be used as part of the system or equipment and that are necessary for support: Description of diagnostic element (e. g., BIT, SIT) computer resource requirements should be included.

4. Brief description of the approach in achieving a total system safety program: Briefly describe the diagnostic impact on system safety as part of the overall description.

5. Human factors, to include personnel planning information and training requirements: Include the diagnostic capability impact on the personnel and training requirements.

Requirement Lessons Learned

Omission of the diagnostic elements in the system engineering management approach usually leads to their omission from the LCC analyses and the program budget. Without funding, the diagnostic element requirements will not be accomplished in a timely, efficient, and sufficient manner.

4.1.3.1.1 System engineering and configuration (PMP Section 4). Verify by inspection that this section of the PMP is correct.

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AFSC P 800-3, Attachment 4.5, contains a checklist that can be used.

3.1.3.1.2 Requirements for test and evaluation (PMP Section 5). Early planning for diagnostic test and evaluation shall be included.

Requirement Rationale

Incorporating diagnostic critical issues, areas of risk, and specific test objectives provides the planning focus and guidance for the DT&E and OT&E to be performed on the system diagnostics. Early planning during the Dem/Val Phase will ensure timely diagnostic evaluation and testing to reduce risks and cost overruns and implementation of required procedures. Additionally, the diagnostic inputs to the PMP will allow for appropriate budgeting of funds to carry out diagnostic test and evaluation.

Requirement Guidance

This requirement is satisfied by analyzing system operational needs and goals using procedures contained in the following policy documents.

DoDD 5000.3	Test and Evaluation
AFR 80-14	Research and Development Test and Evaluation
AFSCP 800-3, atch. 4, 6	A Guide for Program Management

4.1.3.1.2 Requirement for test and evaluation (PMP Section 5). Verify by inspection that central issues, areas of risk, and specific test objectives for diagnostic T&E have been appropriately identified and incorporated into the PMP, Section 5.

Verification Guidance

AFSCP 800-3, Attachment 4.6, furnishes a checklist of information to be included in this section of the PMP.

3.1.3.1.3 Requirements for Integrated Logistics Support (PMP Section 9). The interface between integrated diagnostics and Integrated Logistics Support (ILS, from both design and support aspects, must be identified and implementation procedures must be defined.

Requirement Rationale

The incorporation of integrated diagnostic requirements and plans into the PMP and the logistic program planning provide the up-front baseline focus for the studies and trades required to develop the diagnostic support elements for the system. In addition, the diagnostic inputs to the ILS section will allow for appropriate budgeting of funds to carry out the required analyses under the LSA effort.

Requirement Guidance

This requirement is satisfied through the analysis of system operational needs and preliminary conceptual specifications, based on procedures contained in the following documents:

AFSCP 800-3, Atch. 4, 10	A Guide to Program Management
AFR 800-8, Atch. 5	Integrated Logistics Support (ILS) Program

MIL-STD-1388-1, Task 101 Development of an Early Logistic Support Analysis Strategy.

Additional guidance may be found in 3.1.3.1.3.1 and 3.1.3.1.3.2.

4.1.3.1.3 Requirement for Integrated Logistics Support (PMP Section 9). Verify by inspection that pertinent diagnostic information is incorporated into ILS (Section 9) of the PMP in the appropriate context and level of detail so that a definitive, coordinated diagnostic program is documented.

Verification Guidance

Guidance material in the form of narrative and comparative charts can be developed to assist tailoring a mix of diagnostic design, LSA, and ILS elements for any particular system. This guidance material should address such items as the following.

Identification of the interface between the diagnostic analysis and allocation process in relation to the LSA.

Ensurance that all diagnostic elements are included in the ILS program and sufficient funds exist for development, acquisition, and support of these diagnostic elements.

Verification Lessons Learned

Two examples of logistic shortfalls caused by inadequate planning are lack of funding for producing test program sets and lack of logistic support for ATE.

3.1.3.1.3.1 Diagnostic inputs to the manpower and organization section of the Program Management Plan. Planning to manage the introduction of diagnostic-related manpower requirements shall be provided.

Requirement Rationale

Specific attention is required by the Program Office to plan for appropriate manpower requirements for an effective diagnostic capability.

Requirement Guidance

Section 10, Manpower and Organization, of the Program Management Plan should place proper emphasis on ensuring the fielding of an adequate diagnostic capability for a given weapon system or equipment. This emphasis includes ensuring that the organizational relationship between the Program Office and other Air Force and Government agencies is described. Of particular concern are the relationships to operating commands, the supporting command, and the Air Training Command, which all should contribute to the design of the diagnostic capability. These Air Force organizations, combined with the system/equipment contractors, have the responsibility for deriving diagnostic requirements from weapon system mission and performance requirements. The maintenance concepts and design parameters are the basis for generating manpower requirements. Manpower implications of alternative concepts and designs must be evaluated, and the manpower requirements must be identified and determined to be consistent with program constraints. The maintenance manpower requirements must take into account, and be consistent with, the maintenance testing capability and the technical information supplied to the technician.

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The policy and procedures for the integration and implementation of manpower, personnel, and training considerations are contained in DoD Directive 5000.53, Manpower, Personnel, Training and Safety (MPTS) in the Defense Acquisition Process. The predominant military specification covering the establishment and definition of these requirements is MIL-H-46855, Human Engineering Requirements for Military Systems, Equipment, and Facilities. The Air Force's Integrated Manpower, Personnel, and Comprehensive Training and Safety (IMPACTS) Program provides an approach to jointly addressing manpower, personnel, training, and safety (MPTS) integration issues. The Directorate of Manpower, Personnel, and Training, Deputy for Acquisition Logistics, Wright-Patterson AFB, Ohio, provides technical support to program managers on the application of MPTS activities to their programs. This includes (1) furnishing MPTS expertise and information; (2) providing access to MPTS databases; (3) assistance in developing manpower models and estimates; (4) drafting, reviewing, and commenting on acquisition documents for MPTS impacts; (5) reviewing MPTS items to be included in acquisition documents; (6) reviewing contractor-produced information, data, and deliverables; and (7) analyzing MPTS system configurations and impacts on proposed system MPTS supportability.

Requirement Lessons Learned

In recent programs, the deferral of an adequate fielded diagnostic capability has resulted in the weapon system prime contractor and subcontractors not being required or funded to design this capability. The result has been documented by inferior performance of past weapon system diagnostic capabilities.

4.1.3.1.3.1 Diagnostic inputs to the manpower and organization section of the Program Management Plan. Verify that diagnostic requirements relating to manpower and organization have been included by inspecting the PMP.

Verification Guidance

Inspect and analyze the diagnostic input to the PMP, paying attention to both the Air Force management organization that is charged with responsibility for manpower needs and the methodology used to establish manpower needs for the weapon system. MIL-H-46855 is the governing document.

3.1.3.1.3.2 Diagnostic inputs to personnel and training section of the Program Management Plan. Plans for the training of technicians shall be devised early in the acquisition of a weapon system/equipment.

Requirement Rationale

Special emphasis on developing training procedures for maintenance diagnostics is required to ensure adequate trouble shooting capability for technicians.

Requirement Guidance

DoD Directive 5000.53 establishes policy and procedures for the integration and implementation of MPTS considerations throughout the system acquisition process. As described in 3.1.3.1.3.1, the Air Force's MPT Directorate, through the IMPACTS Program, can provide technical assistance in applying these policies and procedures. Specifically, the Program Office requires inputs from the Air Training Command and operating commands in defining the type, amount, and mix of technician training in maintenance diagnostics. Early planning is required not only to define training requirements but also to ensure that maintenance

training hardware and software are available for system/equipment, demonstrations, test, and evaluations. Alternative support concepts should be considered, such as the following.

On-the-job training vs. formal schooling
Training times, sequences, and schedules for both formal and on-the-job training
Embedded training vs. off-equipment training for on-the-job training

Embedded training for technicians is an alternative for ground equipment.

Discussions with the Air Training Command should emphasize the need for a realistic mixture of formal schooling and on-the-job training, sequenced at appropriate times in the technician's career path. New curricula may be required for formal schooling, and the Air Force Training Command's participation in defining on-the-job training will be required along with the input from more experienced technicians.

4.1.3.1.3.2 Diagnostic inputs to personnel and training section of the Program Management Plan. Verify by inspection that the Program Management Plan contains adequate emphasis on personnel training for troubleshooting and maintenance.

Verification Guidance

Verification guidance is contained in AFSCP 800-3. Be sure to inspect the diagnostic input to the PMP. Pay particular attention to the use of innovative personnel training requirements and procedures to ensure that amount, mix, and type will be considered. Inputs from the Air Training Command and operating commands should be reviewed.

3.1.3.2 Diagnostic segments of the Request For Proposal. The various segments of a Request For Proposal (RFP) that address diagnostic issues shall be prepared.

Requirement Rationale

To ensure that diagnostics receive appropriate emphasis in the system engineering activities of the Dem/Val Phase, the requirements must be placed in contractual documents. With SOW and other RFP provisions and specifications, potential contractors are able to scope, plan, formalize, and price the required diagnostic activities.

Requirement Guidance

Depending upon the program acquisition strategy, a formal Concept Exploration Phase may or may not have been conducted. If a formal Concept Exploration Phase was conducted, the initial diagnostic concept was defined and documented as part of the Testability Analysis Report, per MIL-STD-2165, Task 201.2.4. These outputs should be reviewed and updated for inclusion in the RFP. Several sections of the RFP will be affected by diagnostic requirements, including Special Contract Requirements (Section H), Instructions to Offerors (Section L), and the Evaluation Factors for Award (Section M). The most important and most extensive diagnostic inputs will be made in the SOW, specification, and CDRL. Preparation of the RFP segments for diagnostics requires coordination with design, engineering, and logistic activities to ensure that there are no gaps, overlaps, or conflicts in requirements. Additional guidance is included in Military Handbook 245.

Special Contract Requirements

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Usually, the Special Contract Requirements section of the RFP will require the preparation of a System Engineering Master Schedule (SEMS) to be submitted in response to the RFP, and it is evaluated/negotiated during source selection and subsequently becomes part of the contract. The SEMS consists of a series of selected events or milestones identifying the key engineering tasks for each selected event and the success criteria for each key engineering task. It is a schedule tied to specific development event/milestone, rather than to time. Events/milestones may include the following: System Design Review, Software Specification Review, Preliminary Design Review, Critical Design Review, Functional and Physical Configuration Audits, Test Requirements Review, IOT&E Testing, etc. Key tasks necessary to be completed for each event must be identified and measurable/verifiable criteria for task completion must be defined. These tasks may consist of test plans, support plans, analyses, demonstrations, drawing releases, tests completed, etc. For each task, criteria must be established that defines successful completion of the task. The criteria should be measurable and verifiable. Also, the SEMS can be used to provide a basis for incentives tied to technical accomplishments. The SEMS should be compatible with the System Engineering Master Plan and is the basis for derivation of all subsequent detail planning. Supporting plans are derived from the SEMS. Thus, important integrated diagnostics milestones, the tasks that must be accomplished to achieve them, and the criteria used to verify completion of the tasks must be addressed. Examples of the type of information that should appear in the Dem/Val SEMS are as follows.

1. SOW Task: System engineering design/proofing/prototyping

   Demonstration Milestone: Diagnostic system engineering studies and analyses completed; alternatives selected

   Technical Tasks: Diagnostic allocation to subsystem level and feasibility and risk analyses

   Decision Criteria: See 4.1.3.4

2. SOW Task: System design and validation

   Demonstration Milestone: System Design Review (SDR)

   Technical Tasks: Diagnostic capability defined; SORD, DSRD, and specification diagnostic inputs; and TEMP diagnostic inputs

   Decision Criteria: See 4.1.3.9

The Special Contract Requirements section of the RFP can provide for contractor incentives and warranties aimed at motivating contractors to provide the required diagnostic capability. There are two basic types of warranties, assurance and incentive. Assurance warranties guarantee a specified level of performance, usually a minimum acceptable specification. Incentive warranties provide some motivation for the contractor to improve upon the minimum acceptable specification. The levels of performance that incentives are encouraging contractors to reach are normally stated as goals in the SORD, RCM, DSRD, or specification. This type of incentive warranty is especially appropriate to the concept of diagnostic growth as described in Appendix D, 50.4. AF Regulation 70-11, Weapon System Warranties, establishes the basic policies and procedures for applying weapon system warranties. This regulation is supported by the following guidance documents.

Program Managers' Warranty Guide, 1 September 1989. A guide for the warranty process.

Weapon System Warranty Planning Guide, 1 March 1989. A guide for program managers tasked with developing, coordinating, and approving warranty plans.

DSMC Warranty Handbook. A guide for DoD managers developing, applying, and administering warranties.

The following three specific warranties are required by the weapon system warranty law.

1. Conformance to design and manufacturing requirements
2. Freedom from defects in materials and workmanship
3. Conformance to essential performance requirements

The latter warranty is particularly suited for diagnostic applications, since it is based on verifiable operational, maintenance, and reliability requirements, many of which diagnostics contributes to accomplishing. For each specific warranty, a remedy that the contractor is normally obligated to correct must be established. Each remedy is normally based on field data collection and thus must be supported by an existing data collection system, as defined in 3.1.3.5 of this appendix. Appendix B of the Weapon System Warranty Planning Guide, 1 March 1990, identifies data systems that collect reliability, maintainability, and availability data.

All weapon systems over specified dollar values entering into mature, full-scale production must be covered by a weapon system warranty. However, the intent to use warranties must be established early in the acquisition cycle. Acquisition plans for Dem/Val should address the applicability and planning for obtaining a warranty on production contracts. The provision at this time may be only a framework that identifies the essential performance requirements that will be warranted and the remedies to be invoked to correct defects.

Further information on warranties can be obtained from the Product Performance Agreement Center (PPAC), ASD/ALTE.

Instructions to Offerors

The Instructions to Offerors section of the RFP contains instructions on proposal preparation. Typically, it outlines the required format, page limitations, and content required in the Management, Technical, and Cost proposals. Emphasis must be placed on ensuring that the concept of integrated diagnostics is addressed. Although no standard format exists for this section of the RFP, this section must address the need for managerial and technical information relative to integrated diagnostics and the meeting of the diagnostic requirements. For systems entering development after September 1988, the OSD CALS policy of 5 August 1988 requires specific schedule and cost proposals for integration of contractor technical information systems and processes in acquisition plans, solicitations, and related documents. Contractors must be alerted that they will be judged on how well this integration is planned and how advanced technology will facilitate this integration. Refer to the Air Force CALS Application Guide for required implementation activities and recommended contractual language.

Automation of the diagnostic design process is also of concern because it can provide for a more efficient and effective design process. This can be accomplished by adding provisions to the Instructions to Offerors relating to the following.

A discussion of design aids that will facilitate the design and integration of the diagnostic capability into the system engineering process

The development and use of a diagnostic database that supports the application of these tools

Evaluation Factors for Award

The Evaluation Factors for Awards section must be written to ensure that the proposal writer understands that integrated diagnostics and diagnostic requirements affect the selection of a contractor and must be completely addressed for a proposal to be fully responsive. The evaluation factors should reflect the diagnostic content of the Instructions to Offerors (Section L) from both technical and management points of view. Thus, the evaluation factors must communicate that the proposal will be judged on its approach to integrated diagnostics as part of the system engineering process, along with how advanced technology will be used in technical diagnostic implementation. The evaluation should stress the need for the contractor to identify the manner in which oversight and control of the diagnostic requirements allocation process and design implementation is exercised.

In addition to having the evaluation factors reflect the content of the Instructions to Offerors, several other evaluation factors are important.

The amount and type of specialized testability and integrated diagnostics education and training given to both contractor program managers and designers

The independent research and development conducted by the contractor to investigate testability and diagnostic design tool development and to conduct integrated diagnostic demonstrations

The method and scheduling to be used to ensure the concurrent delivery and evaluation of the prime system together with the entire diagnostic capability

The contractor's method of addressing diagnostics for both GFE and CFE so that overall system diagnostic requirements are met

The quality of the diagnostic maturation program proposed by the contractor

Statement of Work (SOW)

The SOW presents tasks to be performed by the contractor during the development program. The following is a sample SOW for the Dem/Val Phase, which should be tailored before applying to a specific program. The tailoring process may include requirements for the contractor to perform specific activities as presented in the ID Roadmap and as deemed appropriate to apply the necessary emphasis for ID engineering, design, analysis, development, test and evaluation, and documentation.

Sample Dem/Val Phase SOW

Detailed Diagnostic Comparison Analysis

The contractor shall perform a comparison analysis, using the baseline fielded system at each level of field maintenance, to include analysis of the causes of excessive diagnostic times, undetected faults, "false alarms," and "false removals." The contractor shall identify, to the extent practicable, the sources of these causes and describe how the proposed system design and diagnostic capabilities will result in improvements. As a minimum, the contractor should determine whether the causes of diagnostic problems are inherent to the design (i. e., partition-

ing, connectors, etc.), or due to maintenance procedures, a lack of "vertical" testability (e. g., cone of tolerance, compatibility between levels of maintenance), or to transients.

The contractor shall provide quantitative assessments of diagnostic capabilities that identify current capabilities, extrapolations to proposed capabilities, and the engineering analysis that is the basis for the extrapolation. The contractor shall determine where there are overlaps or ambiguities in diagnostic capabilities used for maintenance of fielded systems and how these will be addressed for the proposed system. When deficiencies in the GFE preclude meeting the diagnostic requirements, the contractor shall develop alternatives. In addition, the contractor shall identify the weight and volume of the major external test equipment, type and extent of technical information, and maintenance skill levels and training requirements for currently fielded systems. The contractor shall provide an estimate of these quantities for the proposed diagnostic capability and an explanation of the basis for this estimate.

Diagnostic Risk Reduction

As part of the design, prototype, test, and demonstration activities proposed (the basis of the proposal shall be risk areas identified in Concept Exploration), the contractor shall determine the feasibility of achieving diagnostic capability performance improvements.

Testability, Preliminary Design

The contractor shall apply testability design criteria to the design of items selected for demonstration, in accordance with MIL-STD-2165, Task 202.2.1. The testability design criteria to be considered shall include selective implementation of system-level diagnostic strategies, partitioning to enhance fault isolation, initialization of circuitry under test control, module interface for test access and control, circuit controllability and observability, parts selection, test point placement, and BIT fault detection approaches. The contractor shall develop an approach to establishing vertical test traceability that will ensure compatibility of testing among all levels of maintenance, including factory testing. This approach shall address the compatibility of testing tolerances among levels and the compatibility of testing environments.

Diagnostic Specification Development

As a result of the detailed comparability and design analysis, risk reduction, and preliminary testability design efforts, the contractor shall develop specification requirements that shall allocate diagnostic requirements to applicable design levels. These specifications should address fault detection/isolation, repair verification, performance and condition monitoring, and damage assessment and enable the weapon system to meet maintenance and operational goals. Diagnostic capabilities shall be selected from design techniques (including BIT, fault tolerance, status monitoring, partitioning, test points); external hardware (e. g., automatic and manual test equipment); technical information (e. g., technical information systems and operator displays); and training (e. g., formal schooling, on-the-job training). The capabilities selected may be designed into the system as part of the system or may be provided separately to maintenance personnel, as required, to meet mission and maintenance objectives.

Based on the results of the analyses and risk reduction efforts, the contractor shall specify the diagnostic capabilities to be provided with the system at each level of maintenance and how these capabilities will be allocated, to include the following.

a. Mode of operation (e. g., status monitoring) and areas in which there is a diagnostic ambiguity or overlap

b. Operational test strategies, fault tolerance, prognostics, and fault model assumptions

c. Performance in terms of mean time to diagnose, fault coverage, false alarms, false removals, etc.

d. Physical and functional equipment partitioning requirements

e. Physical (weight, volume) and functional (percent memory) limitations

f. Diagnostic capability interface requirements

g. Options for augmenting GFE diagnostic capabilities

h. Reliability of the embedded test and external diagnostic hardware

Diagnostic requirement development and tailoring is addressed in Appendix B of this standard and in AFGS-87256.

Diagnostic Maturation Plan

This plan shall include the contractor's proposal for refinement of the entire diagnostic capability (hardware and software) beginning with the current program phase and continuing through the achievement of operational diagnostic goals. See Appendix C for details on maturation planning in the IDPP.

Integrated Diagnostics Program Planning

The contractor shall develop an Integrated Diagnostics Program Plan, that describes how the ID program will be conducted. The Program Plan shall be prepared in the format shown in Appendix C. The plan describes the time phasing of each task included in the contractual requirements and its relationship to other tasks. Diagnostic issues that relate to reliability, maintainability, logistics, human engineering, safety, etc., should be addressed in each of these individual program plans.

Diagnostic Program Reviews

As part of the System Design Review, the contractor shall review the diagnostic specification provisions, the diagnostic capability program planning, and the preliminary testability design. Coordinate and conduct diagnostic reviews in conjunction with reliability, maintainability, testability, human engineering, and logistic support reviews, whenever possible. Use MIL-STD-1521 and program review criteria contained in MIL-STDs 470, 785, 1388-1 and 2165 as guidance.

CDRL Recommendations

The following is a recommended list of data deliverables for inclusion in the CDRL.

1. Integrated Diagnostics Program Plan (The only deliverable specifically for diagnostics, it may be included as part of other documents, such as the SEMP, see Appendix C)

2. Updated Diagnostic System and Element-level Specification Provisions and Allocations and Design Requirements

DI-CMAN-80008	System/Element Specifications, MIL-STD 490 (Appendix I), AFGS-87256

3. Proposed Development Subsystem/Assembly Specifications

DE-3102	Configuration Item Development Spec, MIL-STD 490 (Appendices II and III), AFGS-87256 (3.4 and 3.5)
DI-MCCR-80025	Software Requirements Specification, DoD-STD 2167

4. Diagnostic Maturation Plan to include System Testing, Design Analysis, and Data Collection (included in the Integrated Diagnostics Program Plan).

5. Results of Risk Reduction Tasks

DI-T-7199	Testability Analysis Report, MIL-STD 2165, Task 201

6. Results of Comparative Analysis

DI-S-7116	Comparative Analysis Report, MIL-STD 1388-1, Task 203.2

7. Testability Analysis Report, including the following

   Description of approach to achieving vertical testability

   Description of system BIT functional design and system partitioning used to enhance testing

   For each item to be included in this analysis, a description of testability features incorporated (compatibility, observability, controllability, partitioning, etc.), BIT functional design, and BIT interfaces to system BIT and external test

DI-T-7199	Testability Analysis Report, MIL-STD 2165, Task 202

8. Documented results of diagnostic assessment as an integral part of System Design Review documentation

DI-A-7088	Conference Agenda, MIL-STD 1521, Appendix B
DI-A-7089	Conference Minutes, MIL-STD 1521, Appendix B

The above candidate DIDs have been identified to provide the method for contractually obtaining the stated data. In many cases the DID must be tailored to satisfy the diagnostic requirements.

4.1.3.2 Diagnostic segments of the Request For Proposal. Verify by inspection that appropriate diagnostic segments and provisions are in the Dem/Val RFP, including the SOW, Special Contract Requirements, Evaluation Criteria, and Instructions to Offerors.

Verification Guidance

The following checklist should be used.

Is there a requirement for a process to derive FD/FI requirements from weapon system mission and performance requirements and to allocate each diagnostic element?

Does the RFP/SOW relate the importance of integrating the diagnostic elements and of meeting diagnostic requirements?

Does the SOW require preliminary testability design?

Is there a requirement to establish the concept of diagnostic growth and maturation throughout the acquisition period and the initial deployment period?

Does the RFP/SOW reflect the need for detailed baseline comparison analysis and feasibility/risk analysis?

Are all diagnostic elements addressed as an integrated capability as well as individually?

3.1.3.3 Diagnostic segments of program plans. The contractor shall incorporate diagnostic inputs into contractor-prepared program plans.

Requirement Rationale

The Integrated Diagnostics Program Plan (IDPP) is a key diagnostic planning document. Appendix C describes the format and content of an IDPP. As an alternative to a separate IDPP, the required diagnostics planning information may be included in the System Engineering Management Plan (SEMP), ISP, and various other management plans. If an alternative plan is selected in lieu of the IDPP, the following guidance applies. It is also important that relevant portions of the following plans address diagnostic issues, even if a separate IDPP is required.

1. Logistic Support Analysis Plan (LSAP)
2. Reliability Program Plan
3. Maintainability Program Plan
4. Integrated Support Plan (ISP)
5. System Safety Plan
6. Human Engineering Program Plan
7. Avionics Integrity Master Plan

Requirement Guidance

One of the initial contractual efforts undertaken after the award of contract is the preparation of various management plans. Appendix C describes the format of a separate IDPP. An alternative to a separate IDPP is to include information described in Appendix C in the SEMP, ISP, plus various other management plans. If the latter option is used in lieu of the IDPP, the following guidance applies.

Normally, the initial version of the SEMP was prepared during Concept Exploration and, thus, only updating is required. This is also true for the LSAP and the ISP. The other program plans are usually initiated during the Demonstration and Validation Phase.

System Engineering Management Plan

The format of the SEMP is governed by MIL-STD-499 as tailored by the SOW. The SEMP consists of three parts.

APPENDIX A

PART I

Technical Program Planning and Control

This part of the plan should describe the contractor organization and internal interfaces required to implement the design of the diagnostic capability as an integral part of the system engineering process. The extent to which integrated diagnostics has been institutionalized within the contractor's operating policies and procedures must be addressed. This part should identify a single individual who has the overall responsibility and authority for implementing the integration process. The review process ensures that the task is integrated across all involved functional disciplines and that an adequate feedback system exists to redirect efforts to meet diagnostic goals and requirements. Where subcontractors, or teaming arrangements with associate contractors, contribute to the integration of the diagnostic capability, describe these organizational interfaces and the planning and control functions that ensure a totally integrated effort. A schedule should be established for each of the data deliverables cited in the SOW.

PART II

System Engineering Process

This part of the plan should describe the process to be used in meeting the overall program objectives and requirements, the general maintenance concept to be used to support the system/equipment, and the contractor's methodology for arriving at the desired diagnostic approach. Analyses and trade studies should be identified and the proposed procedure for conducting these studies described. Reference to models approved by the procuring activity may satisfy the methodology requirement. If not, these models should be described,along with their capabilities and limitations. The relationship and interface with the logistic support analyses required by MIL-STD-1388-1 should be established.

PART III

Engineering Specialty Integration

This part shall include a detailed description of the integrated diagnostic interrelationships that involve human engineering, personnel, safety, reliability, training, testability, logistics, integrity programs, product assurance, maintainability, etc., and their integration with the system engineering process.

Logistic Support Analysis Plan

The LSAP (see MIL-STD-1388-1, Task 102) should define the interface between the analysis being conducted to define the specification for the diagnostic capability and the LSA.

Reliability Program Plan

Specifically, the Reliability Program Plan should address the failure modes, effect and criticality analysis (FMECA) as the basis for initial diagnostic design. In addition, the reliability modeling task, Task 201, MIL-STD-785, should take into account fault-tolerant design and its relationship to performance monitoring requirements and the relationship to meeting diagnostic goals by using redundancy.

Maintainability Program Plan

The Maintainability Program Plan is a basic planning document for ensuring that diagnostic requirements are met. Each of the MIL-STD-470 200-series tasks has a direct interface with the design of the diagnostic capability. In addition, Task 301, Maintainability Demonstration, and MIL-STD-471A, Interim Notice 2 (USAF), are the basic demonstration tasks for both testability and diagnostics.

Integrated Support Plan

This is the formal planning document for logistics support and is prepared per DI-L-30318 as required by the SOW. It must reflect how all of the diagnostic elements will be provided and supported.

System Safety Plan

The System Safety Plan (MIL-STD-882) should provide inputs that affect the determination and identification of diagnostic requirements for detecting potential safety problems. The performance monitoring analysis should be closely tied to the FMECA.

Human Engineering Program Plan

The Human Engineering Program Plan should address the technician's role and interface with the entire weapon system diagnostic capability, including the time required to access technical information from whatever medium is used. Technicians should evaluate the entire diagnostic capability (at all maintenance levels) during test and evaluation.

4.1.3.3 Diagnostic segments of program plans. Verify that the integrated diagnostic process has been included in the SEMP, IDPP, and into other relevant plans by inspecting these documents.

Verification Guidance

Review the SEMP to see if it provides the following.

1. Provides a vehicle for identifying the contractor's roles and responsibilities, thereby helping direct and control the work of the program.
2. Shows how the parts fit together, providing a basis for coordinating related activities.
3. Is a baseline for any change of scope.
4. Helps everyone know when the objectives have been reached and, therefore, when the effort is complete.

Review of other plans.

IDPP (see Appendix C)

LSAP

Are diagnostic system engineering and analyses an integral part of the LSA process?

Reliability Program Plan

Will FMECA be used as a basis for initial diagnostic design?

Maintainability Program Plan

Have diagnostic issues been addressed adequately in each of the elements of the Maintainability Program Plan listed under Task 101, MIL-STD-470?

Integrated Support Plan

Have all diagnostic elements and support thereof been addressed?

System Safety Plan

Are performance monitoring requirements addressed?

Human Engineering Program Plan

Have all technician diagnostic tasks been identified?

The main evaluation factor is whether the SEMP and other relevant plans demonstrate that integrated diagnostics is truly an integral part of the system engineering process.

Verification Lessons Learned

If front-end analysis and program management does not properly address all aspects of diagnostic capability and organization, there is no ensurance that design and development will lead to the proper mix of diagnostic elements.

3.1.3.3.1 Establish data sharing plans. The contractor shall establish and implement formal data sharing plans to ensure that functional organizations, team members, and subcontractors have access to current diagnostic development information throughout the Dem/Val Phase.

Requirement Rationale

See 3.1.2.3.1.

Requirement Guidance

The acquisition agency should instruct the contractor to define a formal data sharing plan (it can be part of the system engineering management plan or the IDPP). The plan should address the sharing of information used in the design of the weapon system. Appendix F gives examples of the type of data elements and information which are required to perform diagnostic design activities during Dem/Val (data elements listed in Appendix F matrices and that apply to the Dem/Val Phase are those that reference 3.1.3.4). The plan should also address the interface with information regarding the performance of the diagnostic activity as it proceeds through demonstration, test and evaluation, and maturation. The plan should describe (1) the types of information that will be addressed, (2) the sources of this information, (3) the method for sharing this information among the various organizations involved in the design of the diagnostic capability, and (4) the method and frequency of updating the information contained in the data bank.

During the Dem/Val Phase, historical diagnostic implementation characteristics are needed as a lessons learned tool. Other necessary entries into an information system are results of design tradeoff studies; statements of constraints on diagnostic budget in terms of real estate or response time; the criteria for determining whether the diagnostics requirement is satisfied; the apportionment of diagnostic elements, such as percent BIT, ATE, or manual; the systems resources devoted to diagnostics; and incremental design descriptions. Information system aids that facilitate the integration of R&M into the design process should be disclosed.

See 3.1.2.3.1 for further guidance.

Requirement Lessons Learned

See 3.1.2.3.1.

4.1.3.3.1 Establish data Sharing Plans. The formal data sharing plan and implementation shall be verified by inspection.

Verification Rationale

See 4.1.2.3.1.

Verification Guidance

See 4.1.2.3.1.

3.1.3.4 Diagnostic system engineering studies and analyses. Studies and analyses shall be performed to establish and define the diagnostic capability in qualitative and quantitative terms.

Requirement Rationale

For a highly integrated system, Dem/Val is the last opportunity to substantially influence system design. Inclusion of diagnostic considerations in the optimization process (trade studies) ensures that supportability receives adequate attention. Of particular importance are the "embedded" diagnostic elements.

Requirement Guidance

Perform the diagnostic system engineering studies and analyses as an integral part of the weapon system design process. These studies and analyses are a critical component of activities for the diagnostic allocation process described in Appendix B. Technical risk should be identified, and embedded support impact on offline diagnostic elements should be entered into the formal LSA process. Emphasis should be given to the high-risk equipment that is being developed during Dem/Val.

During the Dem/Val Phase, a number of alternative weapon system configurations are studied and analyzed to formulate the preliminary capabilities required to satisfy the weapon system characteristics. In the selection of a weapon system design for FSD, the allocated baseline must include required diagnostic capability.

An iterative process structured to systematically refine all system parameters, including the diagnostic capability, is employed in the formulation of the base candidate for final

optimization. During the Dem/Val Phase, this iterative process should re-evaluate the requirements derived and allocated during Concept Exploration at the system level (and often down to the segment and element levels) and extend this derivation and allocation process down to at least the subsystem level.

To ensure that the groundwork is laid for designing testability into the weapon system, testability design concepts must be established and introduced into the system design. This includes establishing an approach to achieving vertical test traceability. Guidance on performing this activity is contained in MIL-STD-2165, Task 202.2.1, Testability Design Discipline. An approach to vertical testability is contained in Appendix G of this standard. It is recognized that certain items (e. g., high risk) may be developed or modified during Dem/Val. In such instances, vertical testability procedures outlined in Appendix G should be implemented prior to FSD.

Implementation of the Dem/Val diagnostic system engineering studies and analysis program procedures follow the same MIL-STD-499, Section 4, General Criteria, as the Concept Exploration activities, with a different emphasis. In Dem/Val, the emphasis is on quantification of diagnostic element requirements to the allocated baseline. This emphasis is satisfied by applying the generic methodology contained in Appendix B.

Specifically, this requirement can be satisfied through a structured, analytical process based on the generic methodology contained in Appendix B, in conjunction with a multitude of task descriptions and guidance contained with other programmatic military standards and specifications. Of particular applicability is Task 201 of MIL-STD-2165, which addresses establishing testability requirements. Several other military standards and specifications that have a direct interface with deriving diagnostic requirements are listed below.

MIL-STD-470	Maintainability Program for System and Equipment
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-882	System Safety Program Requirements
MIL-STD-1388-1	Logistic Support Analysis
MIL-H-46855	Engineering Requirements for Military Systems, Equipment, and Facilities.

These interfaces are depicted in tables at the end of Appendix B.

The functional descriptions of the alternative diagnostic capabilities generated, in accordance with derived diagnostic requirements, will imply certain innovative technology. Technology gaps and risk factors should be identified during the allocation process. Diagnostic trades during system optimization should consider technical risk as a tradeoff criteria.

Diagnostic element parameters are specified in progressively greater detail as the engineering design optimization process is conducted in conjunction with operational needs, program schedule and budget, producibility, supportability, and life cycle costs.

In applying the guidance contained in Appendix B, follow the following activities (steps).

1. The first action to accomplish when addressing this design level is to determine if any changes or additions have been made to the weapon system's operational needs. If changes or additions have been made, then the activities under 3.1.2.4 should be updated.

2. *Deriving Diagnostic Requirements.* Translation of operational needs and the collation of these needs into diagnostic requirements normally has been accomplished prior to the Dem/Val Phase. For any new design levels addressed in this phase, these steps should be repeated, in particular the collation of all needs into a cohesive set of requirements for each level.

3. *Allocation of Diagnostic Requirements.* At these design levels, the bulk of the diagnostic requirements that were partially implemented earlier (had elements of the diagnostic mix identified to provide the needed diagnostic information) should result in passing down the need for supporting diagnostic information to applicable subfunctions. These requirements should deal mostly with functions. At subsystem levels, requirements should begin to address at least broad groups of hardware/software solutions. Implementation decisions at these design levels should be based on a full range of trades and studies and should begin to lean toward defining groups of solutions. Designers should not be unnecessarily restrained; however, they should keep to the design goals. Some requirements can be implemented at these levels. However, most requirements will be passed in one form or another to lower levels. Care should be used to ensure that the allocated requirements follow the overall diagnostic concept and design goals. Many other design decisions will be made in other areas of concern, such as performance, reliability, cost, weight, size, etc., which will influence the allocation. The allocated requirements should begin to address physical items, in lieu of discussing functions. As the design proceeds, the diagnostic requirements will restrict design options to those solutions that conform to the diagnostic concept and the design decisions that have been made.

If a Failure Mode and Effects Analysis (FMEA) is conducted, per MIL-STD-1629, it can provide valuable data that can be used in the allocation process. It is likely that such an analysis would be restricted to a functional indenture level. Of particular concern will be the Category I (Catastrophic) and Category II (Critical) failures, which affect safety or mission loss. The MIL-STD-1629 tasks most likely to be initiated during Dem/Val and to contribute to the upper design levels are listed below.

Task 101	Failure Mode and Effects Analysis
Task 102	Criticality Analysis
Task 103	FMECA Maintainability Information
Task 104	Damage Mode and Effects Analysis

4.1.3.4 Diagnostic system engineering studies and analyses. Verify by inspection that the weapon system design process includes quantitative values for the diagnostic segments at both system and configuration item levels and that the appropriate tradeoffs have been accomplished. Include assessment of the quality of these studies and analyses.

Verification Guidance

Review the reports dealing with allocation and design requirements resulting from this series of studies and analyses. Use the guidance contained in 20.3 of Appendix B and the following checklist to aid in this review.

1. Are quantitative values assigned at the system level and for each diagnostic element?
2. Is the allocation process closely tied to reliability and maintainability allocations?
3. Did risk analysis address advanced technology considerations?

4. Did the optimization studies address diagnostic performance in relation to cost, manpower, and producibility?

5. Was the analysis interfaced with the LSA?

6. Was the vertical testability concept to be employed established?

7. Were the system partitioning and the BIT functional design described?

Verification Lessons Learned

Failure to verify quantitative diagnostic specifications can lead to costly after-the-fact logistic fixes.

3.1.3.5 Diagnostic maturation and data collection. Plans for diagnostic capability performance data collection, data analysis, and corrective action shall be completed as part of the ID Program Plan.

Requirement Rationale

Diagnostic implementations require maturation time to identify problems and develop corrective actions. This requirement is established to formalize the diagnostics maturation and to allow the maturation to be initiated early in the test and evaluation process.

Requirement Guidance

A program to mature the diagnostic capability should be planned for the development, test, and early fielded production systems. This program should be coordinated with Milestone IV activities as described in DoDI 5000.2. A one- to three-year operational maturation program should be planned for complex weapon systems with extensive automatic testing capability. This program should include provisions for on-site collection of diagnostic performance data with engineering follow up to provide corrective actions.

The plan shall define an approach and methodology to ensure that as development, test and evaluation, and early operational use of the system progresses, problems presented by new failure modes, test voids, ambiguities, and test tolerance difficulties are recognized and defined. The plan should recognize that such occurrences are expected and normal and, therefore, should concentrate on problem recognition, definition, and correction with appropriate tracking for traceability.

The approach and methodology defined shall recognize that a basic element of the integrated diagnostics concept is identification of the set of faults that are known or expected to occur. Provision for growth of this set, as new failure modes are encountered during testing and deployment, should be incorporated in the plan, together with explicit criteria for deciding whether a newly encountered fault should be added to the set of faults for which explicit diagnostic procedures (as opposed to more general procedures) are required. The life cycle cost effectiveness of adding explicit diagnostic procedures for the newly encountered fault should be considered.

The plan should provide for an orderly development and maturation process for the diagnostic capability throughout the development, test and evaluation, and early operational use time periods of the system and its subsystems. Methodology to ensure timely and continuing technical support to this maturation process by both contractor and Air Force cognizant

activities, with a minimum of administrative delays, should be a feature of the plan. Orderly transition of technical responsibilities from contractor to cognizant Air Force technical activities should also be addressed as should transition to the Air Force T. O. 00-35D-54 Material Deficiency Reporting and Investigation System.

The plan should present milestones to be met to ensure that the mature operational system achieves the required degree of diagnostic capability. The plan should show the time phasing of each task and its interrelationship with other tasks. The plan should identify required data, its submittal, review, verification, and use to accomplish tasks and to report on the implementation of testability design features. These reports will enable the procuring activity to monitor and evaluate the contractor's progress toward achieving the required diagnostic capability. The Air Force may establish diagnostic performance incentives throughout the diagnostics development, test, and evaluation process. Milestones selected should include completion of design for testability assessments and other diagnostic system design assessments; completion of diagnostic test element and diagnostic system evaluations, in concert with equipment design evaluation testing at the LRU/subsystem level; and diagnostic system testing, in concert with systems integration test facilities and during the flight test program. The plan should also provide for Air Force evaluation and final acceptance of the automatic test programs and manual troubleshooting procedures in the maintenance T.O.s, during a suitable period after turnover to the user for operational use.

During the Dem/Val Phase, maturation planning is centered on preliminary planning for data collection and analysis and coordination with similar requirements for reliability, maintainability, logistics, data collection, analysis systems, etc. Specifically, this planning should identify potential data sources, such as laboratory testing, developmental testing, operational test and evaluation, acceptance testing, pre-production testing, production testing, operational test, and operation.

The requirement for diagnostic data collection should be coordinated with similar requirements, such as the following.

MIL-STD-785	
Task 104	Failure Reporting Analysis, and Corrective Action (FRACAS)
Task 105	Failure Review Board
Task 301	Environmental Stress Screening
Task 302	Reliability Development/Growth Test (RDGT)
MIL-STD-470	
Task 104	Data Collection, Analysis and Corrective Action
MIL-STD-2165	
Task 103	Testability Data Collection and Analysis Planning
MIL-STD-471	Maintainability Verification/Demonstration/Evaluation
MIL-STD-1388-1	
Task 501	Supportability Test, Evaluation, and Verification
MIL-STD-781	Reliability Design Qualification and Production Acceptance Tests
MIL-STD-2155	Failure Reporting, Analysis, and Corrective Action System.

Planning for the collection of specific information includes data on the overall diagnostics capability, BIT effectiveness, tracking of false faults, CNDs, RTOKs, false removals, ATE effectiveness, and integration of the diagnostic elements. The following list can be used to prepare a specific list of diagnostic data requirements for a particular program. Appendix F has examples of specific types of data elements that should be considered in formulating a diagnostic feedback database. The data elements in Appendix F that apply are those that

reference 3.1.3.5. Requirements for data collection and storage at a specific design level or maintenance level are contained in AFGS-87256, section 3.

Diagnostic Data Feedback

1. Diagnostic effectiveness in actual operation and maintenance environment

   Are system FD/FI requirements being met?
   Are diagnostic resources provided consistent with the training/skill levels of assigned personnel?
   Does BIT provide timely and accurate detection of faults to minimize reliance on manual detection (e.g., squawks)?
   Are BIT false alarms adversely impacting operational availability and maintenance workloads?
   Are faults detected at one level of maintenance also detected at the next level of maintenance?
   Does BIT support MTTR and system availability requirements?
   Does ATE and associated TPS support shop throughput requirements?
   Is the maintenance technician supplied with technical information in a timely and efficient manner?
   Does poor resolution for BIT and ATE reduce spares availability?
   Is poor BIT reliability adversely affecting the mission?

2. BIT effectiveness

   Did BIT detect the failure?
   Did BIT correctly indicate which mission functions were lost?
   Did BIT provide accurate fault isolation information for corrective maintenance actions?
   What was the ambiguity size (number of modules to be removed or further tested) due to fault localization/isolation by BIT?
   How much time was required for fault isolation at the Organizational Level of maintenance?

3. Tracking of false alarms

   What are the characteristics of alarm types?
   What is the frequency of alarm occurrence?
   What are the potential consequences of ignoring the alarm (crew safety, mission reliability)
   What are the operational costs of responding to the false alarm (aborted missions, degraded mode operation, system down time)?
   What are the support costs associated with false alarm (resulting expenditure of maintenance manhours (MMH), support equipment time, spares)?
   What additional data is available from operational software dumps (software failure occurrences, branch histories, interrupt histories)?
   Has the system environment (or the understanding of the system environment) changed since the system's tolerances or transient characteristics were specified?
   What were the operating conditions and environment when the alarm occurred?

4. ATE effectiveness feedback

Were any workarounds required to overcome mechanical or electrical deficiencies in the UUT/ATE interface?
Was the documentation for UUT hook-up and power-up procedures accurate?
Did the ATE system provide failure detection results consistent with those of the initial failure detection by BIT?
Were the ATE test results repeatable?
Did the ATE system (in conjunction with any module BIT) provide accurate fault isolation?
Were the observed test results documented in the maintenance documentation? Was the failed component listed under the observed test result in the maintenance documentation?
What was the ambiguity group size (number of components to be removed or further tested) due to fault isolation by the ATE system?
How much time was required for fault isolation?

Diagnostic data collection and diagnostic capability performance assessment most often leads to the requirement for corrective action. Corrective action may involve redesign of prime equipment, test equipment, interface devices, maintenance documentation, BIT circuits, diagnostic software, and ATE test programs. All changes must be made in accordance with standard configuration control procedures.

Refer to Appendix C for further guidance on diagnostic maturation planning.

Requirement Lessons Learned

Experience with major Air Force systems shows that data collection systems have not focused on diagnostics. They have been manual and, therefore, cumbersome to implement and maintain. They have been dependent upon human motivation and interpretation.

4.1.3.5 Diagnostic maturation and data collection. Verify by inspection that the contractor's approach to diagnostic data collection and maturation is comprehensive and realistically scheduled.

Verification Rationale

Inspection is the only effective method for reviewing the adequacy of the Maturation Plan.

Verification Guidance

Inspect the Diagnostic Maturation Plan using the following checklist.

Flight Test/IOT&E

a. Contractor maintenance of the system and diagnostic capability (minimum work-arounds)

b. Incentive milestone for diagnostic capability to support IOT&E activities

c. Test and evaluation programs defined and implemented to demonstrate that average-capability technicians can use the diagnostic system effectively

d. Special problem reporting and maintenance activity reporting, with positive tracking, defined and provided by the contractor

e. Diagnostic problem solving linked to problem and maintenance activity reporting

f. Diagnostic system elements are under Class 2 configuration control for software; Class 1 for hardware, after hardware PCA

g. AFOTEC monitoring of the diagnostic system starts in IOT&E while contractor evaluates/corrects

In the Production/Deployment Phase, the following activities should be planned for later implementation.

Initial Operation Use (OT&E for two- to three-year period)

a. Special reporting of contractor/user problems with contractor on-site technical assistance

b. Enhanced Maintenance Data Collection System (e.g., 66-1) reporting of maintenance actions

c. Streamlined Government control of TPS and BIT/SIT change activity; link to problem reporting with a positive tracking system

d. Incentive contracted responsibility for resolving all identified problems; incentives linked to measurable integrated diagnostic parameters (e.g., MTTR, CND/RTOK, False alarm Rates, MMH/FH)

e. Contractor works problems with SPO/AFLC monitoring

f. Transitioning of data system from contractor to Air Force finalized

Full Operational Use

a. T. O. 0035D-54 Material Deficiency Reporting and Investigation System reporting of problem symptoms

b. Contractor/AFLC engineering team works problems under SPO/SM direction pre/post PMRT

c. Enhanced Maintenance Data Collection System reporting of maintenance actions

d. Contract Formal OT&E of depots as organic capability achieved

3.1.3.6 Diagnostic segments to specifications. The results of Dem/Val effort shall be introduced into the diagnostic segments of specifications for Full Scale Development.

Requirement Rationale

Continuation of the diagnostic capability acquisition into the FSD Phase depends on establishing requirements that can be incorporated into the solicitations, proposals, and contracts for that phase.

Requirement Guidance

System and element specifications are to be updated using the guidance contained in Appendix A of AFGS-87256, 3.1, 3.2, and 3.3. Profiles of development specifications for subsystem and assembly/element levels are to be prepared using the guidance contained in Appendix A of AFGS-87256, 3.5 and 3.6.

4.1.3.6 Diagnostic segments to specifications. Verify that diagnostic inputs have been made to the system specifications by inspection.

Verification Rationale

Inspection is an effective way to verify that diagnostic requirements have been entered into the specifications.

Verification Guidance

See Appendix A of AFGS-87256, 4 for verification of specific diagnostic requirements that lead to the creation of diagnostic related specifications.

3.1.3.7 Diagnostic inputs to the System Operational Requirements Document. Update diagnostics inputs to the System Operational Requirements Document (SORD).

Requirement Rationale

The SORD is the requirements and planning document that addresses operational and support needs. It amplifies and refines the SON. The SORD and its attached Requirements Correlation Matrix (RCM) document and track the goals and requirements that influence the design of the diagnostic capability. Therefore, diagnostic inputs to the SORD must be updated to establish a sound basis for developing and tracking the diagnostic capability.

Requirement Guidance

Use AFR-57-1, Operational Needs, Requirements, and Concepts, as a guide. An RCM is attached to the SORD. Formats for both the SORD and the RCM are included in AFR-57-1. The RCM lists parameters and requirements that the system must have to accomplish its intended mission. It is used to document and track the formulation of and changes to these user requirements as they evolve through the program acquisition process.

Attachment 6 to AFR-57-1 provides the format for the SORD. The content of the SORD evolves with the design of the weapon system. The initial version is required at Milestone I. Inputs relative to the system's diagnostic capability should be reflected throughout the SORD. Particular attention should be paid to the paragraph dealing with combat or mission reliability and maintainability. This paragraph discusses the need for different performance capabilities, depending on mission profiles and environmental conditions. These performance capabilities are some of the major requirements that influence the design of the diagnostic capability.

The format for the RCM is contained in Attachment 8 to AFR-57-1. The RCM contains both requirements and goals, which become requirements as the design of the weapon system progresses. The RCM is a key part of the diagnostic maturation process (see Appendix C). Updates to the SORD and RCM should be based on the results of tradeoffs and analyses that define the diagnostic capability.

Update SORD diagnostic inputs with two concerns. First, address the general concepts and needs that will be expanded or clarified by the RCM parameters. Second, avoid specifying diagnostic-only requirements until trades or analyses have been made to determine values that best support operational needs. Appendix E, 60.2, lists operational parameters, along with their diagnostic impact, that should aid in updating diagnostic statements for the SORD.

Requirement Lessons Learned

Diagnostic requirements are usually only one facet of a higher operational or support requirement (e.g., fault isolation is actually a component of requirements for mission capable rates, utilization rates, man hours per flying hour, etc.). By specifying proper operational and support parameters in the SORD and RCM and by ensuring contractors use these parameters in a system engineering approach, the resultant diagnostic capability will support the operational requirements without unnecessarily constraining contractors.

4.1.3.7 Diagnostic inputs to the System Operational Requirements Document. Verify that appropriate diagnostic inputs are included by inspecting the SORD and RCM.

Verification Rationale

Inspection is the most effective verification method, as guidance is included in AFR-57-1 and in the following checklist .

Verification Guidance

Inspection of inputs to the SORD/RCM should be the responsibility of the implementing command. Guidance in AFR-57-1 should be followed, in addition to the following checklist.

1. Are the proper operational and support parameters specified to drive development of diagnostic requirements? See Appendix E, 60.2

2. Are any diagnostic-only requirements based on mission needs and operational constraints and are they verifiable?

3. Are diagnostic issues, goals, and requirements reflected throughout the SORD for all elements that make up the diagnostic capability?

4. Have provisions for diagnostic growth been included?

Verification Lessons Learned

Establishment of inadequate or inappropriate diagnostic requirements often result in an inadequate diagnostic capability.

3.1.3.8 Update diagnostic inputs to the Depot Support Requirement Document. Update diagnostic inputs to the Depot Support Requirement Document (DSRD).

Requirement Rationale

The DSRD is the planning document for Depot support. It supports the SON and the SORD. Diagnostic inputs to the DSRD must be updated to ensure the plans and requirements for providing both depot maintenance and material support are adequate.

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Requirement Guidance

Use AFR-57-1, Operational Needs, Requirements, and Concepts, as a guide. The DSRD is prepared and issued in parallel with the SORD. Attachment 9 to AFR-57-1 is the format for preparing the DSRD. The content of the DSRD evolves with the design of the weapon system. The initial version is required at Milestone I. The system's diagnostic capability should be reflected throughout the DSRD for all diagnostic elements used in the depot. Particular attention should be paid to the concept of vertical testability that, at depot level, promises the use of ATE common with that used at other maintenance levels. This topic should be addressed under the MATE section of the DSRD (Section 2d of Attachment 9 to AFR-57-1).

Requirement Lessons Learned

Improper attention paid to early planning for Depot support can result in lengthy and costly periods for transitioning from contractor to Air Force support.

4.1.3.8 Updating of diagnostic inputs to the Depot Support Requirements Document. Verify that appropriate updates of diagnostic inputs are included by inspecting the DSRD.

Verification Rationale

Inspection is the most effective verification method. Guidance is included in AFR-57-1 and the checklist that follows.

Verification Guidance

Verification is achieved by inspection and analysis of inputs to the DSRD by responsible persons. This verification should be the responsibility of the implementing command. Guidance in AFR-57-1 should be followed. The following checklist may help.

1. Has the concept of vertical testability been introduced?

2. Have the diagnostic elements which compose the diagnostic capability been integrated?

3.1.3.9 Diagnostic segment of System Design Review. The System Design Review (SDR) shall include a complete review of the planned development of the diagnostic capability.

Requirement Rationale

A diagnostic review during the SDR provides an effective evaluation of the diagnostic work accomplished during the Dem/Val Phase and the data needed to specify realistic diagnostic parameters for the FSD Phase.

Requirement Guidance

Procedures identifying the diagnostics-related items that must be included as part of the SDR shall be provided, per MIL-STD-1521.

4.1.3.9 Diagnostic segment of the System Design Review. Verify by inspection that the proper methods are used to ensure that the diagnostics segment of the SDR will correctly evaluate the preliminary diagnostic concept of the emerging system/equipment.

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Verification Rationale

Inspection is the most effective verification method during an SDR.

Verification Guidance

MIL-STD-1521, Appendix B, provides procedures and guidance for conduct ing a SDR. The procedures and listed items should be reviewed from a diagnostic perspective. The following checklist may be helpful.

1. Does the contractor have a corporate policy identifying procedures for internal reviews as well as customer required reviews?

2. Is emphasis being placed on technical interchange meetings between contractor and customer rather than on large-scale reviews?

3. Are qualified diagnostic technical experts, who can challenge the design and assess risks, included in these reviews?

4. Are diagnostic reviews held as an integral part of the Prime System Review?

Verification Lessons Learned

Omission of a diagnostic concept review and evaluation during the SDR indicates a lack of diagnostics understanding. This lack of understanding will then propagate into the Validation Phase documents and requirements and result in a less-than-desirable diagnostic capability.

3.1.3.10 Diagnostic inputs to the Test And Evaluation Master Plan. Diagnostic inputs to the Test and Evaluation Master Plan (TEMP) must be updated.

Requirement Rationale

Test and evaluation is an essential part of the diagnostic capability maturation and verification processes. Therefore, it is imperative that diagnostic issues be addressed in the TEMP.

Requirement Guidance

DoDD 5000.3 requires the preparation of a TEMP. This directive is amplified by AFR-80-14, Research and Development Test and Evaluation. The TEMP is the basic planning document for all test and evaluation related to a particular system acquisition. During Dem/Val, test and evaluation issues play a significant role in selecting the preferred diagnostic alternatives. Emphasis should be placed on high-risk development efforts that will be conducted during the subsequent acquisition phases.

DoD Directive 5000.3-M-1 contains the guidelines for the preparation of the TEMP. Chapter 2 contains the format for the TEMP, in which Part III relates to DT&E and Part IV deals with OT&E. Each of these parts deals with a significant number of diagnostic issues, such as reliability, maintainability, logistics, safety, software, and training. LSA Task 501, "Supportability, Test, Evaluation and Verification," is a source of data for making inputs to the TEMP. Ensure, especially at OT&E, that the entire diagnostic capability will be evaluated. MIL-STD 1388-1, Tasks 501.2.1 and 501.2.2 (Supportability Test, Evaluation and

Verification) data outputs can be used to formulate a T&E strategy and establish T&E objectives.

Further procedures and guidance relating to test and evaluation of the diagnostic capability are contained in Appendix D, 50.4. The material relating to DT&E and OT&E should be addressed in the TEMP, as applicable.

Requirement Lessons Learned

Initiating the TEMP during the early phases of the weapon system acquisition ensures that the contractor and the Air Force understand that test and evaluation of diagnostic capability will be an important factor. Thus, attention will be given to the timely development of the entire diagnostic capability.

4.1.3.10 Diagnostic inputs to the Test and Evaluation Master Plan. Verify the adequacy of diagnostic inputs that have been made to the TEMP.

Verification Rationale

Inspection of this plan is the only method available to verify its validity.

Verification Guidance

Use DoD Directive 5000.3-M-1 and the following checklist to verify the adequacy of the TEMP.

1. Have diagnostic-related inputs to the TEMP been included?
2. Have high-risk items been given special consideration?
3. Has emphasis been placed on evaluation of the entire diagnostic capability as a whole?
4. Is there a logical relationship between the TEMP and the Diagnostic Maturation Plan?

Verification *Lessons Learned*

Without proper verification of the TEMP, diagnostic test and evaluation may not occur in a timely and effective fashion.

3.1.3.11 Diagnostic inputs to the Decision Coordinating Paper. Diagnostic inputs to the Decision Coordinating Paper (DCP) shall be prepared prior to authorization for beginning FSD.

Requirement Rationale

The impact of the diagnostic goals and thresholds defined during Dem/Val on the weapon system operational parameters must be known by the reviewing authority to facilitate decisions regarding weapon system design, support system design, and funding requirements during FSD.

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Requirement Guidance

Diagnostic DCP input guidance is provided in DoD Instruction 5000.2, F9, and in Enclosure 4 to this instruction.

4.1.3.11 Diagnostic inputs to the DCP. Verify by inspection that the impact of the diagnostic capability is included in the DCP.

Verification Guidance

As part of the DCP/IPS submittal process, inspect the documents to verify that the diagnostic impact has been included. The inspection procedures shall be included as part of the DCP/IPS submittal process contained in AFSCP 800-3.

3.1.4 Full-Scale Development Phase

3.1.4.1 Diagnostic segments of the Program Management Plan. Diagnostic inputs to the Program Management Plan (PMP) must be generated/updated.

Requirement Rationale

Integrating diagnostic requirements in the applicable sections of the FSD Phase PMP permits planning, management, and specifying of diagnostic tasks. This integration enables diagnostic tasks to be properly funded, performance to be reviewed, and parametric value FD/FI levels to be specified prior to development.

Requirement Guidance

For acquisition programs that are initiated at the FSD Phase, this guidance can be used to define inputs to the diagnostic-relevant sections of the PMP. For acquisition programs continuing from a Dem/Val Phase, this guidance can be used to update the diagnostic-relevant sections of the PMP for the FSD Phase. This requirement is broken into sub-requirements addressed in 3.1.4.1.1 through 3.1.4.1.3.2 below.

Applicable guidance is contained in the following documents

MIL-STD-499, para. 5.1, 10.1	Engineering Management
MIL-STD-1388-1, task 101	Development of an Early Logistic Support analysis Strategy.
AFSC P 800-3, atch 3, 4	A Guide for Program Management
AFR 800-2, atch 3	Instructions for Developing and Preparing a PMP
AFR 800-8, atch. 5	ILS Program
AFR 800-12	Acquisition of Support Equipment
AFSC/AFLC R 800-23, para. 4	Policy for Modular Automatic Test Equipment
AFLC/AFSCP 800-34, ch. 7	Acquisition Logistics Management
AFR 80-14	Test and Evaluation

4.1.4.1 Diagnostic segments of Program Management Plan. Verify that diagnostic requirements have been incorporated by inspecting applicable sections of the PMP.

Verification Guidance.

The PMP sections identified in the requirement should be inspected for sufficiency and correctness of the diagnostic requirements. The inspection should be conducted using guidance provided in the military standards and Air Force regulations and pamphlets identified in 3.1.4.1 above.

3.1.4.1.a Modification planning. The approach to satisfying diagnostic requirements must be included in modification plans.

Requirement Rationale

Prime systems and equipment being modified may also require modifications to their diagnostic capabilities.

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Requirement Guidance

System and equipment modification plans, Classes III, IV, and V, are documented in a Time Compliance Technical Order (TCTO), in accordance with AFR 57-4, Modification Approval and Management. Pay attention to the following when preparing this document.

Adequacy of the present diagnostic mix at each maintenance level

Possible diagnostic hardware and software changes based on prime equipment modifications and their integration (e.g., vertical test compatibility).

Test and evaluation of the entire diagnostic capability relating to the prime equipment modifications.

Fielding of modified diagnostic capability concurrently with modified prime equipment.

Requirement Lessons Learned

The diagnostic implications of system and equipment modifications can adversely impact performance, cost, and schedule if not managed properly.

4.1.4.1.a Modification planning. Verify by inspection that diagnostic implications have been addressed in the TCTO.

Verification Guidance

Use AFR 57-4.

3.1.4.1.1 System engineering and configuration (PMP Section 4). Diagnostic capability must be included in the system engineering management approach in the PMP.

Requirement Rationale

Since the integrated diagnostics process is intertwined into the prime system/equipment system engineering process, it should be included as part of the program effort that is defined in this section of the PMP.

Requirement Guidance

Ensure the following topics are included in the system engineering management approach. Included with each identified topic is the diagnostic element relationship.

Topic 1

Describe the program effort for defining the preferred system configuration (system definition), engineering/technical management, and the integration of engineering and specialty programs.

Include, as appropriate, the identification of both the embedded and external diagnostic elements in the program effort description.

Topic 2

Include summaries on plans for risk reduction programs, technical reviews and studies, and analyses (particularly life cycle cost analyses).

Diagnostic Relationship

Diagnostic-peculiar tradeoffs (e.g., BIT vs. offline ATE) and diagnostic-related portions of tradeoffs and analyses should be included in the summaries or plans.

In the summary of the planned approach for engineering and engineering management, include the diagnostic relationship, as appropriate, for each topic shown below.

1. Engineering definition of the complete system

   Include the diagnostic elements as part of the engineering definition.

2. Reliability, maintainability, human engineering, vulnerability, value engineering, quality assurance, integrity, testability, producibility, and technical performance measurement

   Include, for each topic, the appropriate diagnostic element impact.

3. Computer, computer programs, and associated documentation to be used as part of the system or equipment and that are necessary for support

   Description of diagnostic element (e.g., BIT, SIT) computer resource requirements should be included.

4. Brief description of the approach in achieving a total system safety program

   Briefly describe the diagnostic impact, as appropriate, on system safety as part of the overall description.

5. Human factors, to include personnel planning information and training requirements

   Include the diagnostic capability impact on the personnel and training requirements.

4.1.4.1.1 System engineering and configuration (PMP Section 4). Verify that the System Engineering and Configuration section of the PMP addresses diagnostic elements by inspecting the document.

Verification Guidance

Refer to AFSCP 800-3, Attachment 4.5, for a checklist that can be used.

3.1.4.1.2 Test and evaluation (PMP Section 5). Test and Evaluation (T&E) shall be planned to ensure diagnostic procedures and resources are in place.

Requirement Rationale

This requirement provides planning focus and guidance for the DT&E and OT&E to be performed on the system diagnostics. Planning will ensure timely diagnostic evaluation and

testing to reduce risks and cost overruns and to implement required procedures. Diagnostic inputs to the PMP will allow for appropriate budgeting of funds to conduct diagnostic test and evaluation.

Requirement Guidance

Analyze the system's operational needs and goals based on procedures contained in the following.

DoD 5000.3	Test and Evaluation
AFR 80-14	Research and Development Test and Evaluation
AFSCP 800-3, Atch. 4, 6	A Guide for Program Management

Requirement Lessons Learned

Omitting pertinent diagnostic-critical issues, areas of risk, and specific test objectives will result in the following.

Omission of necessary funding to provide the resources and management required to perform diagnostics T&E

Inadequate diagnostics T&E for risk reduction, establishment of test tolerance to eliminate Cannot Duplicates (CND) and implementation of activities needed for diagnostic maturation

4.1.4.1.2 Test and evaluation (PMP Section 5). Verify that central issues, areas of risk, and specific test objectives for diagnostics T&E have been appropriately identified and incorporated by inspecting the PMP, Section 5.

Verification Rationale

Inspection is the best way to verify proper contents of the PMP.

Verification Guidance

Ensure that diagnostics T&E segments (i.e., issues, areas of risk, and specific test objectives) reflect system operational goals, needs, constraints, environment, and requirements. AFSCP 800-3, Attachments 4 and, 6 furnishes a checklist of information to be included in this section of the PMP.

3.1.4.1.3 Integrated Logistics Support (PMP Section 9). Implementation procedures for the interface between integrated diagnostics and Integrated Logistics Support (ILS) shall be identified and defined from both design and support aspects.

Requirement Rationale

This requirement provides the up-front baseline focus for the studies and trades needed to develop integrated diagnostics design requirements and to identify the diagnostic support elements for the system. This allows appropriate budgeting of funds to conduct proper LSA analyses.

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Requirement Guidance

Analyze the system's operational needs and preliminary conceptual specifications based on procedures contained in the following

AFSCP 800-3, Atch. 4, 10	A Guide to Program Management
AFR 800-8, Atch. 5	Integrated Logistics Support (ILS) Program
MIL-STD-1388-1, Task 101	Development of an Early Logistic Support Analysis Strategy.
AFR 800-12	Acquisition of Support Equipment

This requirement is subdivided in 3.1.4.1.3.1. and 3.1.4.1.3.2. below.

Requirement Lessons Learned

Top management attention is critical to proper budgeting of funds to perform the system engineering analyses and follow-on LSAR data development for logistics support acquisition. Omission of diagnostic planning in the ILS Section 9 of the PMP will mean loss of diagnostic visibility at high management levels. A predictable result is loss of system readiness in the field due to insufficient O&M funding to keep pace with the maintenance burden (i. e., sparing, CNDs, TPS support load).

4.1.4.1.3 Integrated Logistics Support (PMP Section 9). Verify that pertinent diagnostic information is incorporated into the ILSP or ILS, Section 9, of the PMP, by inspecting this section.

Verification Rationale

Inspection is the most effective way to verify contents of the PMP.

Verification Guidance

Ensure a definitive, coordinated diagnostics program is documented. Guidance material, in the form of narrative and comparative charts, needs to be developed to assist in tailoring a mix of the roles of diagnostic design, LSA, and ILS elements for any particular system. This guidance material should address such items as the following.

Identification of the interface between the diagnostic analysis and allocation process in relation to the LSA

Ensurance that all diagnostic elements are included in the ILS program and sufficient funds exist for development, acquisition, and support of these diagnostic elements

3.1.4.1.3.1 Manpower and organization (PMP Section 10). Diagnostic manpower requirements shall be introduced into the Manpower and Organization Section of the PMP.

Requirement Rationale

Specific attention is required by the Program Office to ensure the acquisition of an effective diagnostic manpower capability.

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Requirement Guidance

The Air Force organizational relationship between the Program Office and other Air Force and Government agencies should be described. Of particular concern are the relationships to the operating commands and the Air Training Command. These Air Force agencies, and the system/equipment contractors, have the responsibility for deriving diagnostic requirements from weapon system mission and performance requirements. These diagnostic requirements affect manpower requirements. Manpower implications of alternative concepts and designs should be evaluated and the requirements should be identified and determined to be consistent with program constraints. The maintenance manpower requirements should be consistent with the maintenance testing capability and the technical information supplied to the technician. The policy and procedures for the integration and implementation of manpower, personnel. and training considerations are contained in DoD Directive 5000.53, Manpower, Personnel, Training , and Safety (MPTS) in the Defense Acquisition Process. MIL-H-46855, Human Engineering Requirements for Military Systems, Equipment, and Facilities, covers establishing and defining these requirements.

Requirement Lessons Learned

Lack of the proper emphasis by the Air Force Program Offices and associated Air Force organizations on an adequate field diagnostic capability has resulted in contractors not paying adequate attention to the design of this capability. The result has been inferior performance of weapon system diagnostic capabilities.

4.1.4.1.3.1 Manpower and organization (PMP Section 10). Verify that diagnostic requirements relating to manpower and organization have been established by inspecting the PMP, Section 10.

Verification Guidance

Particular attention should be paid to both the Air Force Management organization, which is charged with the responsibility for manpower needs, and the methodology used to establish manpower needs for the weapon system. MIL-H-46855 is the governing document.

3.1.4.1.3.2 Personnel training section of PMP. Plans for training technicians shall be devised and included in the Personnel Training section of the PMP.

Requirement Rationale

Special emphasis on developing training procedures related to maintenance diagnostics is required to improve the fielded diagnostic capability of a weapon system.

Requirement Guidance

DoD Directive 5000.53 establishes policy and procedures for the integration and implementation of MPTS considerations throughout the system acquisition process. As described in 3.1.3.1.3.1, the Air Force's MPT Directorate, through the IMPACTS Program, can provide technical assistance in applying these policies and procedures. Specifically, the Program Office requires inputs from the Air Training Command and operating commands to define the type, amount, and mix of technician training in maintenance diagnostics. Planning is required to define training requirements and to ensure that maintenance training hardware and software are available for system/equipment tests, demonstration, test and evaluations. Consider alternative support concepts, such as the following.

Use of on-the-job training vs formal schooling
Training times, sequences, and schedules for both formal and on-the-job training
Embedded training vs off-equipment training for on-the-job training

Investigate innovative training techniques to provide more productive diagnostic capabilities. Consider a mixture of formal schooling and on-the-job training, sequenced at appropriate times in the technician's career path. Discussions with the Air Training Command should emphasize the need for a realistic mixture. New curricula may be required for formal schooling. The Air Force Training Command's participation in defining on-the-job training will be required, along with inputs from experienced technicians.

4.1.4.1.3.2 Personnel training section of PMP. Verify by inspection that the PMP contains adequate emphasis on personnel training for troubleshooting and maintenance.

Verification Guidance

Guidance is contained in AFSCP 800-3, Attachments 4 and 12. Be sure to inspect and analyze the diagnostic input to the PMP. Pay particular attention to the use of innovative personnel training requirements and procedures to ensure that amount, mix, and type will be considered. Inputs from the Air Training Command and operating commands should be reviewed.

3.1.4.2 Diagnostic segments of the RFP. The various segments of an RFP that address diagnostic issues shall be prepared.

Requirement Rationale

The RFP, which leads to contract requirements, is the key form of communication between the Government and the contractor. Proper inclusion and placement of diagnostic requirements in the RFP is key to achieving desired diagnostic goals.

Requirement Guidance

Depending upon the program acquisition strategy, a formal Dem/Val Phase may or may not have resulted in diagnostic segments of the RFP or an overall diagnostic concept for the system or the diagnostic elements. If a formal Dem/Val Phase was conducted and resulted in such outputs, then these outputs must be updated and reviewed for inclusion in the RFP. If not, then each diagnostic segment RFP section must be prepared and coordinated with other design, engineering, and logistic segments. Several sections of the RFP will be affected by diagnostic requirements, including Special Contract Requirements (Section H), Instructions to Offerors (Section L), and Evaluation Factors for Award (Section M). Preparation of the RFP segments for diagnostics may also require coordination with other design, engineering, and logistic activities to ensure that there are no gaps, overlaps, or conflicts in requirements. Additional guidance is in Military Handbook 245.

Special Contractual Requirements

Usually, the Special Contract Requirements section of the RFP will require the preparation of a System Engineering Master Schedule (SEMS) to be submitted in response to the RFP, and it is evaluated/negotiated during source selection and subsequently becomes part of the contract. The SEMS consists of a series of selected events or milestones identifying the key engineering tasks for each selected event and the success criteria for each key engineering task. It is a schedule tied to specific development event/milestone, rather than to time. Events/milestones

may include the following: System Design Review, Software Specification Review, Preliminary Design Review, Critical Design Review, Functional and Physical Configuration Audits, Test Requirements Review, IOT&E Testing, etc. Key tasks necessary to be completed for each event must be identified. Verifiable criteria for task completion must be identified. These tasks may consist of test plans, support plans, analyses, demonstrations, drawing releases, tests completed, etc. For each task, criteria must be established that defines successful completion of the task. The criteria should be measurable and verifiable. Also, the SEMS can be used to provide a basis for incentives tied to technical accomplishments. The SEMS should be compatible with the System Engineering Management Plan. It is the basis for derivation of all subsequent detail planning. Supporting plans are derived from the SEMS. Thus, important integrated diagnostics milestones, the tasks that must be accomplished to achieve them, and the criteria used to verify completion of the tasks must be addressed. Examples of the type of information that should appear in the FSD SEMS are listed below.

a. SOW Task: Preliminary design

   Demonstration milestone: Diagnostic preliminary design completed

   Technical Tasks: Final diagnostic allocation, embedded diagnostic design, and inherent testability assessment

   Decision criteria: See 4.1.4.4

b. SOW Task: System/subsystem design review

   Demonstration milestone: Preliminary design review

   Technical Tasks: Ensure diagnostic capability performance requirements are met and specification diagnostic inputs are made

   Decision criteria: See 4.1.4.6

c. SOW Task: Detail design

   Demonstration milestone: Diagnostic detail design completed

   Technical Tasks: Design embedded diagnostic capability, establish vertical testability requirements, make diagnostic provisions to specifications

   Decision criteria: See 4.1.4.7

d. SOW Task: System/subsystem/equipment design review

   Demonstration milestones: CDR, TRR

   Technical Tasks: Ensure all hardware and software diagnostic performance requirements are met; product specification inputs are made; and SORD, DSRD and TEMP diagnostic inputs are made

   Decision criteria: See 4.1.4.10 and 4.1.4.10.1

e. SOW Task: Fabricate/integrate weapon system

Demonstration milestone: Fabricate external diagnostic elements

Technical Tasks: Offline testing capability, technical information delivery system, manpower and training capability, technical information development

Decision criteria: See 4.1.4.11 through 4.1.4.11.4

f. SOW Task: Test and evaluation

Demonstration milestones: Diagnostic segments of DT&E completed, diagnostic segments of OT&E completed, maintainability demonstration completed

Technical Tasks: Test and evaluation of external diagnostic capability, demonstration of external diagnostic capability

Decision criteria: See 4.1.4.12.1 through 4.1.4.12.3

The Special Contract Requirements section of the RFP can provide for contractor incentives and warranties aimed at motivating contractors to provide the required diagnostic capability. There are two basic types of warranties, assurance and incentive. Assurance warranties guarantee a specified level of performance, usually a minimum acceptable specification. Incentive warranties provide some motivation for the contractor to improve upon the minimum acceptable specification. The levels of performance that incentives are encouraging contractors to reach are normally stated as goals in the SORD, RCM, DSRD, or specification. This type of incentive warranty is especially appropriate to the concept of diagnostic growth as described in Appendix D, 50.4. AFR 70-11, Weapon System Warranties, establishes the basic policies and procedures for applying weapon system warranties. This regulation is supported by the following guidance documents.

Program Managers' Warranty Guide, 1 September 1989. A guide for the warranty process.

Weapon System Warranty Planning Guide, 1 March 1989. A guide for program managers tasked with developing, coordinating, and approving warranty plans.

DSMC Warranty Handbook. A guide for DoD managers developing, applying, and administering warranties.

The following three specific warranties are required by the weapon system warranty law.

1. Conformance to design and manufacturing requirements
2. Freedom from defects in materials and workmanship
3. Conformance to essential performance requirements

The latter warranty is particularly suited for diagnostic applications, since it is based on verifiable operational, maintenance, and reliability requirements, many of which diagnostics contributes to accomplishing. For each specific warranty, a remedy that the contractor is normally obligated to correct must be established. Each remedy is normally based on field data collection and thus must be supported by an existing data collection system, as defined in 3.1.3.5 of this appendix. Appendix B of the Weapon System Warranty Planning Guide, 1 March 1990, identifies data systems that collect reliability, maintainability, and availability data.

All weapon systems over specified dollar values entering into mature, full-scale production must be covered by a weapon system warranty. However, the intent to use warranties must be established early in the acquisition cycle. During FSD a more complete model provision that sets forth all the warranty terms and conditions should be included in the RFP. If feasible, a weapon system warranty should be considered for use during FSD. Such a warranty would probably be an incentive type and should include the following items.

Interaction of the diagnostic design process with automated system design, including establishing and using a shared database

Interactive design of all elements of the diagnostic capability with the prime system design

Concurrent delivery and evaluation of the entire diagnostic capability along with the prime system for the maintainability demonstration and IOT&E

Further information on warranties can be obtained from the Product Performance Agreement Center (PPAC), ASD/ALTE.

Instructions To Offerors

The Instructions to Offerors section of the RFP contains instructions on proposal preparation. Typically, it outlines the required format, page limitations, and content required in the Management, Technical, and Cost proposals. Ensure that the concept of integrated diagnostics is addressed. Although no standard format exists for this section of the RFP, this section must address the need for managerial and technical information relative to integrated diagnostics and the meeting of diagnostic requirements. For systems entering development after September 1988, the OSD CALS policy of 5 August 1988 requires specific schedule and cost proposals for integration of contractor technical information systems and processes in acquisition plans, solicitations, and related documents. The contractor must know that he will be judged on how well this integration is planned and how advanced technology will facilitate this integration. Refer to the Air Force CALS Application Guide for required implementation activities and recommended contractual language.

Separate costing of diagnostic activities/tasks in the cost proposal increases management visibility of integrated diagnostics efforts. A separate breakout of costs is not always reasonable, due to the interdisciplinary nature of the diagnostic tasks. However, certain activities are appropriate, such as costing of technical manual development (see Summary Report on the Defense-Wide Audit on Acquisition of Technical Manuals and Related Data from Contractors, Office of the Inspector General, No. 87-115, April 3, 1987), TPS development, and diagnostic growth efforts. These are appropriate for the FSD Phase RFP.

Automation can provide a more efficient and effective design process. Encouraging the use of automation can be accomplished by adding provisions to the Instructions to Offerors relating to the following.

A discussion of design aids which facilitate the design and integration of the diagnostic capability into the system engineering process

The development and use of a diagnostic database that supports the application of these aids

Evaluation Factors for Award

The Evaluation Factor for Award section must ensure that the proposal writer understands that integrated diagnostics and diagnostic requirements will have a significant impact on contractor selection. Evaluation factors should reflect the diagnostic content of the Instructions to Offerors (Section L) from both technical and management points of view. Evaluation factors must communicate that the proposal will be judged on its approach to integrated diagnostics as part of the system engineering process, along with how advanced technology will be used. The evaluation should stress the need for the contractor to identify the manner in which oversight and control of the diagnostic requirements allocation process and design implementation is exercised.

Several other evaluation factors are important, such as the following.

The amount and type of specialized education and training given to both contractor program managers and designers relating to testability and integrated diagnostics

Independent research and development conducted by the contractor relating to testability and diagnostic design tool development and integrated diagnostics demonstrations

Method and scheduling to ensure the concurrent delivery and evaluation of the entire diagnostic capability with the prime system

How diagnostics for both GFE and CFE will be addressed by the contractor to ensure overall system diagnostic requirements are met

Quality of the diagnostic maturation program proposed by the contractor

Statement of Work

The SOW presents tasks to be performed by the contractor during the development program. The following is a sample SOW for the FSD Phase, which should be tailored before applying to a specific program. The tailoring process may include requirements for the contractor to perform specific activities as presented in the ID Roadmap and as deemed appropriate to apply the necessary emphasis for ID engineering, design, analysis, development, test and evaluation, and documentation.

Sample FSD Phase SOW

Design of the Diagnostic Capability

As part of the system design, the contractor shall incorporate embedded diagnostic and testability features and provide external diagnostic capabilities that satisfy the diagnostic performance requirements in the system specification.

Diagnostic Design Analysis

The contractor shall implement a structured design analysis process to assess in detail the ability of the diagnostic design to meet the system diagnostic performance specification (e.g., fault coverage, mean time to diagnose, false removal, etc.); analyze the inherent testability of the preliminary design; identify areas where the primary means of diagnostics may lead to an ambiguous result and ways the ambiguity will be resolved; identify areas in which there is a redundant (overlapping) diagnostic capability; and verify that the detailed design of diagnostics

is in accordance with the functional allocation established during the previous program phase. As a minimum, the analytical task shall be performed and delivered as described below.

Design Analysis of Diagnostics Built into the System

The contractor shall complete a structured analysis of system design implementation to identify functional areas in which diagnostic requirements allocated in the previous phase provide an unambiguous capability to detect or isolate a fault to the appropriate replaceable unit at each level of maintenance. As a minimum, the design analysis shall be based on maintenance dependency models (or their equivalents) at the system level to quantify the degree of ambiguity at the lowest replaceable assembly and to assess inherent testability of the design (Tasks 202 and 203 of MIL-STD-2165), in which there are large areas of ambiguity. In electronic assemblies consisting of digital logic, the dependency model analysis shall be augmented with 100 percent fault simulating for selected samples. In addition, the contractor shall prepare a worst case analysis of design or tolerance margins at each BIT sensor and test point for the system. The outcome of these analyses should include an assessment of the capability of the built-in diagnostics to meet the fault coverage specification, an identification of specific system areas in which there is ambiguous fault detection or isolation, and an assessment of the capability to limit the false alarms and false removals. These assessments should identify the projected causes of false alarms and false removals and ambiguities in terms attributable to equipment design mechanization (including partitioning, test point placement, BIT limitations), transients, or maintenance and operational considerations. These analyses will be used to update the diagnostic functional allocation, where necessary, to resolve ambiguities or reduce overlap. These analyses shall be completed by the CDR.

Assessment of External Diagnostics

At the CDR, the contractor shall deliver detailed requirements for external test equipment, troubleshooting approaches to be included in maintenance manuals, TIDS, and training. These requirements shall be supported by a diagnostic ambiguity analysis to be delivered at the same time. The analysis shall describe the degree to which diagnostic ambiguities are reduced and areas in which there is redundancy (overlap) of diagnostic capabilities. The analysis shall highlight those areas where the combination of embedded and external diagnostics cannot unambiguously detect or isolate a fault within the prescribed diagnostic limits. Its results, modified as necessary to resolve ambiguities, will be used to update requirements for external diagnostics.

The contractor shall implement the concept of vertical testability to ensure compatibility of testing among all levels of maintenance, including factory testing. Both compatibility of the testing tolerances among levels and the testing environments must be considered. The results of this effort must be documented in a Test Requirement Document per MIL-STD-1519. Specific links among all levels must be established and documented as referenced and outlined in Appendix G.

Diagnostic Maturation Program

The contractor shall establish and maintain a diagnostic performance data collection system and conduct diagnostic performance verification tests and demonstrations, in accordance with MIL-STD-470, Task 301, to evaluate the effectiveness of the diagnostic design. As a minimum, diagnostic testing should include the insertion of a complete fault sample (approaching 100 percent at each maintenance level, as costs permit) in customer-selected areas of the system to

evaluate the accuracy of the fault coverage prediction. In addition, diagnostic testing should include system operation throughout the specified environmental range in order to evaluate false alarm and removal deficiencies. Maintainability demonstrations during DT&E and OT&E and the total diagnostic capability, both embedded and external, should be evaluated concurrently with the weapon system.

Monitor diagnostic performance whenever the system is operating and determine whether the diagnostic capabilities are operating in accordance with the design. The contractor shall take corrective action as necessary to meet diagnostic capability requirements. The contractor shall provide a diagnostic maturation profile, periodic summary of diagnostic performance throughout the development cycle, and results of the diagnostic verification.

The diagnostic performance data collection system shall extend through the FSD, Production, and Deployment Phases. The data system shall be designed so that the performance of the diagnostic capability can be ascertained at any point during the acquisition, production, and deployment of the weapon system. It shall be compatible with the established DoD data system, which will be employed after the maintenance of the weapon system becomes the responsibility of the Government.

The contractor shall also plan for the transition of responsibility to the Government for the collection and analysis of diagnostics data. The contractor shall make available to the Government all failure analysis and trending data collected as a result of this task. The data shall be delivered in a digital format acceptable to the government. Field data collection and analysis should be automated as most practical and cost effective.

The system shall be integrated to the maximum extent practical with similar data collection requirements specified elsewhere.

Integrated Diagnostic Program Plan

The contractor shall develop and maintain an IDPP, that describes how the diagnostic program will be conducted. The Program Plan shall be in accordance with the format in Appendix C. The plan describes the time phasing of each task included in the contractual requirements and its relationship to other tasks. Diagnostic issues that relate to reliability, maintainability, logistics, human engineering, safety, etc., should be addressed in plans for these disciplines.

Diagnostic Program Reviews

As part of the formal reviews (e.g., PDR, CDR) that are conducted during FSD, the preliminary and detail design of the diagnostic capability shall be addressed. These reviews shall be coordinated and conducted in conjunction with reliability, maintainability, human engineering, and logistic support reviews, whenever possible. Use MIL-STD-1521 and program review criteria contained in MIL-STDs 470, 785, 1388-1, and 2165 as guidance.

CDRL recommendations.

The following is a recommended list of data deliverables for inclusion in the CDRL.

PDR

1. Embedded diagnostics design assessment results
   a. DI-MCCR-80012 Diagnostic Element CSCI Top-Level, DOD-STD-2167
   b. DI-T-7199 Testability Analysis Report, MIL-STD 2165, Task 202

c. DI-E-3102	Prime Item Development Specifications(s), MIL-STD 490
d. DI-E-3102	Critical Item Development Specifications (s), MIL-STD 490

2. External Diagnostic Capability Requirements

a. DI-L-7147	Personnel & Skill Summary Report, MIL-STD 1388-2 (LSA-002)
b. DI-L-7151	Support Equipment Requirements MIL-STD 1388-2 (LSA-013)
c. DI-L-7177	Maintainability Analysis - Level-of-Repair-Report, MIL-STD 1388-2 (LSA-053)
d. DI-L-7178	Failure Mode Analysis Summary Report, MIL-STD 1388-2 (LSA-054)
e. DI-L-7179	Failure Modes Detection Summary Report, MIL-STD 1388-2 (LSA-055)

3. Vertical Testability

a. DI-ATTS-80041	Test Requirements Document, MIL-STD 1519, Notice 2, including linking tables as referenced and described in Appendix G

System/Subsystem CDR(s)

1. Embedded diagnostic design assessment results

a. DIR-MCCR-80031	Diagnostic Element CSCI Software Detailed Design Document, DOD-STD-2167
b. DI-E3103	Draft Prime Item Product Fabrication Specification(s), MIL-STD 490
c. DIE-30132	Draft Critical Item Product Fabrication Specification(s), MIL-STD 490
d. DI-T-7199	Detailed Testability Analysis, MIL-STD 2165, Tasks 202 and 203

2. External Diagnostic Capability Requirements
   a. Update of PDR documents

3. Documented Diagnostic Design Assessment during CDR

a. DI-A-7088	Conference Agenda, MIL-STD 1521, Appendix E
b. DI-A-7089	Conference Minutes, MIL-STD 1521, Appendix E

Subsystem FCA (s)

1. Update Diagnostic Performance Specification(s)

a. DI-E-3103	Prime Item Product Fabrication Specification, MIL-STD 490
b. DI-E-30132	Critical Item Product Fabrication Specification, MIL-STD 490

T&E

1. DI-R-7113	Diagnostic Capability Demonstration Results, MIL-STD 470, Task 301

2. Updated Diagnostics Capabilities Field Maturation Plan

DIDs identified above must be tailored to ensure that diagnostic requirements are included.

4.1.4.2 Diagnostic segments of RFP. Verify adequacy and completeness of the diagnostic input by inspecting the FSD RFP.

Verification Rationale

Ensure that the contractor performs the required diagnostic activities and incorporates specified requirements in the final design.

Verification Guidance

The following checklist should be used.

1. Does the RFP/SOW relate the importance of integrating the diagnostic elements and of meeting the diagnostic requirements?

2. Is there a requirement that the design of the total diagnostic capability be completed and evaluated as a whole for OT&E?

3. As a minimum, is there a requirement that the Maturation Program extend through transitioning of the system to Air Force maintenance, to include operating and transitioning the performance data collection system?

3.1.4.3 Diagnostic segment of program plans. Integrated diagnostic requirements shall be incorporated into various contractor-prepared program plans.

Requirement Rationale

The Integrated Diagnostics Program Plan (IDPP) is a key diagnostic planning document. Appendix C describes the format and content of an IDPP. As an alternative to a separate IDPP, the required diagnostics planning information may be included in the SEMP, ISP, and various other management plans. If an alternative plan is selected in lieu of the IDPP, the following guidance applies. The SEMP is the preferred plan for describing how integration of the diagnostic elements is implemented. However, at this point, relevant portions of the following plans must also address this issue.

1. Logistic Support Analysis Plan
2. Reliability Program Plan
3. Maintainability Program Plan
4. Integrated Support Plan
5. System Safety Plan
6. Human Engineering Program Plan
7. Avionics Integrity Master Plan

Requirement Guidance

One of the initial contractual efforts undertaken after the award of contract is the preparation of various management plans. Appendix C describes the content of a separate IDPP. An alternative to a separate IDPP is to include appropriate information in the SEMP, ISP, and various other management plans. If the latter option is used in lieu of the IDPP, the following guidance applies.

APPENDIX A

Normally, the initial version of the SEMP was prepared during Concept Exploration and updated during Dem/Val; thus, only updating is required. This is also true for the LSAP and the ISP. The other program plans were usually initiated during the Dem/Val Phase.

System Engineering Management Plan

The requirement for the SEMP, governed by MIL-STD-499, is composed of three parts.

PART I

Technical Program Planning and Control

This part of the plan should describe the contractor(s) organization and internal interfaces required to integrate the design of the diagnostic capability as an integral part of the system engineering process. The extent to which integrated diagnostics has been institutionalized within the contractor's operating policies and procedures must be addressed. A single person should be identified who has the overall responsibility and authority for implementation of the integration process. This person should be the one with the responsibility for the other aspects of weapon system performance. A review process should be described to ensure that the task is integrated across all involved functional disciplines and that an adequate feedback system exists to redirect efforts to meet diagnostic goals and requirements. Where subcontractors, or teaming arrangements with associate contractors, contribute to the integration of the diagnostic capability, describe these organizational interfaces and the planning and control functions to be implemented to ensure a totally integrated effort. A schedule should be established for each of the data deliverables cited in the Statement of Work.

PART II

System Engineering Process

This part of the plan should contain a description of the process to be used in meeting the overall program objectives and requirements, the general maintenance concept to be used to support the system/equipment, and the contractor's methodology for arriving at the desired diagnostic approach. Analysis and trade studies should be identified, and the proposed methodology for conducting these studies should be described. Reference to models approved by the procuring activity may satisfy the methodology requirement. If not, these models should be described, along with their capabilities and limitations. In addition, the plan should include the following.

1. An integrated approach to the maintenance diagnostics design that is an integral part of the system/subsystem design

2. A description of how diagnostic requirements are to be met and integrated with each other and with the overall weapon system design. This shall include procedures for identifying deficiencies, needed actions, and corrective measures

3. A description of how diagnostic elements are integrated with each other into a cost-effective achievement of primary maintenance goals (e.g., 100 percent unambiguous fault isolation capability)

PART III

Engineering Specialty Integration. This part should include a detailed description of the integrated diagnostic interrelationships involving human engineering, personnel, safety, reliability, training, logistics, product assurance, maintainability, testability, integrity programs, etc., and their integration with the system engineering process. The plan should address the need for combined demonstration programs (e.g., reliability, maintainability).

LSAP (MIL-STD-1388-1). Define how the integration of data and analysis resulting from LSA and other system engineering efforts will be accomplished.

Reliability Program Plan. Address the conduct of the failure modes, effects, and criticality analysis (FMECA) as the basis for initial diagnostic design. The reliability modeling task, Task 201, MIL-STD-785, should take into account fault-tolerant design and its relationship to performance monitoring requirements and meeting diagnostic goals by utilizing redundancy.

Maintainability Program Plan. The basic planning document for ensuring that diagnostic requirements are met. Each of the MIL-STD-470 200-series tasks has a direct interface with the design of the diagnostic capability. Task 301, Maintainability Demonstration, is the basic demonstration task for both testability and diagnostics.

Integrated Support Plan. The formal planning document for logistic support is prepared per DI-L-30318 as required by the SOW. It must reflect how all of the diagnostic elements will be provided and supported.

System Safety Plan (MIL-STD-882). Provide diagnostic inputs that impact the determination and identification of diagnostic requirements for detecting potential safety problems. This performance monitoring analysis should be closely tied to the FMECA.

Human Engineering Program Plan. Address the technician's role/interface with the entire weapon system diagnostic capability, including the time required to access technical information from whatever media is used. Careful attention must be paid to have technicians evaluate the entire diagnostic capability (at all maintenance levels) during test and evaluation.

4.1.4.3 Diagnostic segment of program plans. Verify by inspection that the integrated diagnostic process has been included in the SEMP, IDPP, and into other relevant plans.

Verification Guidance

Review the SEMP to determine if it provides the following.

1. A vehicle for identifying the contractor's roles and responsibilities, thereby helping direct and control the work of the program.

2. A description of how the parts fit together, providing a basis for coordinating related activities

3. A baseline for any change of scope

4. Help for everyone to know how to determine when the objectives have been reached and, therefore, when the effort is complete

Review of other plans.

Integrated Diagnostics Program Plan (see Appendix C)

Logistics Support Analysis Plan

Are diagnostic system engineering and analyses an integral part of the LSA process?

Reliability Program Plan

Will FMECA be used as a basis for initial diagnostic design?

Maintainability Program Plan

Have diagnostic issues been addressed adequately in each of the elements of the Maintainability Program Plan listed under Task 101, MIL-STD-470?

Integrated Support Plan

Have all diagnostic elements and support thereof been addressed?

System Safety Plan

Are performance monitoring requirements addressed?

Human Engineering Program Plan

Have all technician diagnostic tasks been identified?

The main evaluation factor is whether the SEMP and the other relevant plans demonstrate that integrated diagnostics is truly an integral part of the system engineering process.

3.1.4.3.1 Develop/Update data sharing plans. The contractor shall establish and implement formal data sharing plans to ensure that functional organizations, team members, and subcontractors have access to current diagnostic development information throughout the FSD Phase.

Requirement Rationale

See 3.1.2.3.1.

Requirement Guidance

The acquisition agency should instruct the contractor to define/update a formal data sharing plan (it can be part of the system engineering management plan or the IDPP). The plan should address the sharing of information used in the design of the weapon system. Appendix F gives examples of the type of data elements and information that are required to perform diagnostic design activities during FSD (data elements listed in Appendix F matrices and that apply to the FSD Phase are those that reference 3.1.4.4, 3.1.4.7 and 3.1.4.11). The plan should also address the interface with information regarding the performance of the diagnostic activity as it proceeds through demonstration, test and evaluation, and maturation. The plan should describe (1) the types of information that will be addressed; (2) the sources of this information; (3) the method for sharing this information among the various organizations involved in the

design of the diagnostic capability; and (4) the method and frequency of updating the information contained in the data bank.

During the FSD Phase, results of design tradeoff studies and incremental design descriptions are necessary entries into an information system. Information system aids that facilitate the integration of R&M into the design process should be disclosed. Provisions should be made for feedback of data from evaluations, testing, and field use. Its collection and use should be firmly and formally embedded via feedback into the design process. This data should evaluate the diagnostic design efficiency in light of results from development testing, manufacturing, and field testing.

See 3.1.2.3.1 for further guidance.

Requirement Lessons Learned

See 3.1.2.3.1.

4.1.4.3.1 Develop/Update data sharing plans. The formal data sharing plan and implementation shall be verified by inspection.

Verification Rationale

See 4.1.2.3.1.

Verification Guidance

See section 4.1.2.3.1.

3.1.4.4 Diagnostic preliminary design. The contractor shall perform cohesive, integrated diagnostic design to develop the total diagnostic capability necessary to meet weapon system requirements as part of preliminary design for the prime system.

Requirement Rationale

Diagnostic capability cuts across many functional disciplines. Without a conscious effort to establish a cohesive diagnostic design process, there is a potential for increased life cycle costs due to gaps and incompatibilities within the fielded diagnostic capability.

Requirement Guidance

The diagnostic design process embraces both the prime equipment design and supporting disciplines. It is not the intent of this requirement to establish diagnostics as a "super" discipline that attempts to swallow up a number of supporting disciplines. However, it is necessary to clearly establish those components of reliability, maintainability, integrity, integrated logistics support, testability, human engineering, safety, training, and technical data that have a diagnostic interface, so that products of these activities are integrated into one cohesive diagnostic capability. It is also essential that documentation of these products use a format that serves the needs of all users.

Incorporating diagnostic capability design into preliminary design involves coordinating a number of engineering specialties to produce a cohesive diagnostic design. This coordination must provide a diagnostic capability that is apportioned between embedded and external diagnostics to provide a goal of 100 percent fault detection and isolation at each maintenance

level. The goal of 100 percent unambiguous fault detection and isolation is approached through a planned diagnostic maturation process.

There are several diagnostic design activities performed during prime system preliminary design that support the cohesiveness and integration of the diagnostic capability. These diagnostic design activities fall into three categories: diagnostic allocation, embedded diagnostic design, and diagnostic maturation. Each is discussed below.

Diagnostic Allocation

Preliminary design is essentially the final chance to allocate diagnostic requirements down to the lowest design levels and to reallocate at all levels, if necessary. At this point in system design, major emphasis should be placed on allocation at the assembly design level.

Implementation of the diagnostic preliminary design procedures follow MIL-STD-499, 4, General Criteria. Emphasis is on quantification of diagnostic element requirements (both embedded and external). This emphasis can be satisfied by applying the generic methodology contained in Appendix D. Guidance on implementing diagnostic requirements can be found in AFGS-87256, Section 3.

Specifically, this requirement can be satisfied through a structured analytical process based on the generic methodology contained in Appendix B, in conjunction with a multitude of task descriptions and guidance contained in other programmatic military standards and specifications. Of particular applicability is Task 201 of MIL-STD-2165, which addresses establishing testability requirements. Several other military standards and specifications that have a direct interface with deriving diagnostic requirements are listed below.

MIL-STD-470	Maintainability Program for Systems and Equipment
MIL-STD-785	Reliability Program for Systems and Equipment development and Production
MIL-STD-882	System Safety Program Requirements
MIL-STD-1388-1	Logistic Support Analysis
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment, and Facilities

These interfaces are depicted in tables at the end of Appendix B.

Diagnostic element parameters are specified in progressively greater detail as the engineering design optimization process is conducted, in conjunction with operational needs, program schedule and budget, producibility, supportability, and life cycle costs.

In applying the guidance contained in Appendix B, the following activities (steps) should be undertaken. However, the first action to accomplish when addressing this design level is to determine if any changes or additions have been made to the weapon system's operational needs. If changes or additions have been made, then the previous allocation activities should be updated.

1. Deriving Diagnostic Requirements. Translation of operational needs and the collation of these needs into diagnostic requirements normally has been accomplished prior to the FSD Phase. For any new design levels addressed in this phase, these steps should be repeated, in particular the collation of all needs and requirements into a cohesive set of requirements for each new design level.

2. Allocation of Diagnostic Requirements. At the assembly level allocation should focus on implementing diagnostic requirements. Failure Mode and Effects Analysis is an important source of data in performing allocation at this design level. Task 101, of MIL-STD-1629 (FMEA), results in identifying item failures, classifying each potential failure according to its severity, and identifying the method failure detection. Task 102 of this standard (FMECA) provides a means for establishing a probability of failure occurrence based on best available data. Data obtained from these analyses are a solid source for allocation of diagnostic requirements to both embedded and external diagnostic elements.

The external diagnostic capability required to complement the embedded diagnostic capability should be defined in terms of maintenance manual-documented troubleshooting procedures, offline test equipment, TIDS, and training requirements. Requirements need to be formulated and analyzed to achieve the most effective and efficient diagnostic coverage prior to transmittal to the responsible activity. The MATE program establishes the procedures, tools, computer programs and documentation to provide the Air Force the capability to acquire and develop external automatic test systems (MATE Acquisition Handbook, Volume II).

Embedded Diagnostic Design

During preliminary design, embedded design concepts should be incorporated into the design for each configuration item. Consider the following system-level considerations: maintenance concept for each level of maintenance; use of reconfigurability and redundancy to meet safety and reliability requirements; quantitative diagnostics-related performance parameters (i. e., ambiguity group size, failure latency, fault detection coverage, fault isolation time); and system status monitoring/reporting. Test sequence must be formulated to achieve an optimum fault isolation strategy. Software tools, such as the Navy's Integrated Diagnostic Support System's (IDSS) Weapon System Testability Analyzer (WSTA) are available to assist in formulating this strategy.

Testability design concepts need to be incorporated. Inputs to the system architecture alternatives' impact on inherent testability should be made. Diagnostic architecture considerations, such as testability bus, system-level BIT, onboard diagnostic data collection, and sensor locations should be addressed. The Navy's Testability Analysis Handbook gives guidance on implementing MIL-STD-2165.

Other embedded diagnostic design considerations, such as incorporating expert diagnostic system technology, technical information delivery systems, and on-the-job training, should be addressed.

Diagnostic Maturation

System design activity should include a methodology or mechanism to correct any diagnostic shortfall that may be encountered. For example, inherent testability analysis may uncover design deficiencies and modifications undertaken.

4.1.4.4. *Diagnostic preliminary design.* Verify by analysis and inspection that the appropriate preliminary design tasks related to diagnostics have been satisfactorily addressed.

Verification Rationale

Many disciplines that are governed by independent military specifications and standards require coordination to achieve effective and efficient diagnostic capability for all levels of maintenance. Inspecting the diagnostic design process is required to verify that this has been

achieved. In addition, analyses can be conducted to verify that adequate testability design has been achieved.

Verification Guidance

A two-part verification is envisioned. The first part concerns the diagnostic design process, which is controlled by a sizable number of military specifications and standards. The tables contained in 20.6 of Appendix B can be used to determine that the interfaces among the various logistic support and engineering disciplines have been adequately addressed during the allocation process. Additionally, guidance for verifying diagnostic requirements can be found in AFGS-87256, Section 4.

The second part of the verification deals with inherent testability assessment. MIL-STD-2165, Task 202 contains an approach to evaluating preliminary design characteristics that support test and testability requirements: the Inherent Testability Assessment. The methodology is contained in Appendix B of MIL-STD-2165. The methodology is a checklist of design features and is a powerful tool for evaluating testability features. Implementing the checklist involves tailoring to make criteria design specific, weighting checklist items in terms of their overall and relative contribution to testability, setting an inherent testability threshold, and selecting items to be included in the assessment. The contractor (design engineer) tailors the checklist and assigns weights to checklist items, both subject to Government review and approval. The Government sets the threshold and selects items to be included in the assessment. Based upon Government and contractor concurrence on these items, the design engineer completes the checklist. An engineering level of effort is required to complete the checklist.

Other methodologies are available to evaluate preliminary testability design. There are other checklist approaches. Automated analysis tools are available, such as the Navy's IDSS Weapons System Testability Analyzer, that can be used to perform topological analysis (i.e., test point analysis observability/ controllability analyses, etc.) and test strategy adequacy.

3.1.4.4.1 Diagnostic inputs to hardware and software specifications. The results of the preliminary design must be documented in the appropriate specifications.

Requirement Rationale

The design process is an iterative (design-test-redesign) and phased (preliminary and detail) process. In order to proceed from one phase to the next, documentation must be developed and/or updated. To proceed from the preliminary design phase to the detail design phase, development specifications containing quantified diagnostic parametric values must be reviewed and updated.

Requirement Guidance

Guidance for tailoring diagnostic requirements for input to specification development update is contained in AFGS-87256, 3.

4.1.4.4.1 Diagnostic inputs to hardware and software specifications. Verify by inspection that the results of the diagnostics preliminary design are documented in the revised versions of the appropriate development specifications.

APPENDIX A

Verification Guidance

See 4.0 of AFGS-87256.

3.1.4.5 Diagnostic data collection and maturation planning. Appropriate segments of the Diagnostic Maturation Program shall continue to be planned and implemented.

Requirement Rationale

Diagnostic capability assessment must be made in conjunction with the prime system performance assessment. The diagnostic data collection and maturation approach must coincide with the prime system assessment approach, e.g., DT&E, OT&E, Production, and Deployment. Close coordination with Milestone IV activities as described in DoDI 5000.2 is essential.

Requirement Guidance

Ensure that as development, test and evaluation, and early operational use of the system progress, problems presented by new failure modes, test voids, ambiguities, test tolerance difficulties, and interface between the diagnostic elements are recognized and defined and that their solutions are traceable to needed diagnostic improvements.

Detailed guidance on planning the Diagnostic Maturation Program is in 3.1.3.5 and Appendix C. In the FSD Phase, applicable portions of this plan are implemented. The Government must monitor and review this implementation at the technical reviews and audits conducted during FSD and in the results of the maintainability demonstrations. Appendix F has examples of specific types of data elements that should be considered in formulating and maintaining a diagnostic feedback database. The data elements in Appendix F that apply are those that reference 3.1.4.4.7. Requirements for data collection and storage at a specific design level or maintenance level are contained in the AFGS-87256, Section 3.

Specifically, the items to be implemented and reviewed include the following.

The diagnostic elements as they are developed (For each diagnostic element, identify failure modes, test voids, ambiguities, test tolerance difficulties, and interface deficiencies)

The level of capability and the integration of that capability through development test and evaluation

A diagnostic data collection system and the integration of that system with similar data collection systems

Diagnostics performance assessment

Corrective action implementation, as required

Data Collection, Analysis, and Corrective Action Reports (MIL-STD 470, Task 104) will contain documentation on the results of these efforts.

Increasing weapon system complexity makes diagnostic data collection more difficult and more expensive. Automated concepts should be considered to make data collection more feasible. With these automated concepts, the data collection may be designed-in. Automation aspects

include user-transparent data collection, trend analysis, statistical analysis, and correlation. The development of the automated data collection must start early. Often system and diagnostic element links must be provided.

Requirement Lessons Learned

Historically, data collection systems have not been effective. They have not focused on diagnostics. They have been manual and, therefore, cumbersome to implement and maintain. They have depended on human motivation and interpretation. They have also been very expensive.

4.1.4.5 Diagnostic data collection and maturation planning. Verify diagnostic data collection and maturation plans by inspection and analysis.

Verification Guidance

See 4.1.3.5

3.1.4.6 Preliminary Design Reviews. The diagnostic preliminary design shall be reviewed to ensure it meets the specified diagnostic capability for the individual configuration item (CI) or aggregate of CIs.

Requirement Rationale

Upon completion and approval of the PDR results, the allocated baseline is established. In order to establish a valid allocated baseline, the diagnostic capability, in terms of parametric values for the particular CI or aggregate of CIs reviewed, must be evaluated.

Requirement Guidance

The PDR is a formal technical review of the basic design approach for a CI or for a functionally related group of CIs. It is held after the Hardware Development Specification(s), the Software Top-Level Design Document, the Software Test Plan, the Hardware Configuration Item Test Plan, the preliminary versions of the Computer System Diagnostic Manual, and Computer Resources Integrated Support Document are available, but prior to the start of detail design. Review the above documents for diagnostic element content and compliance with requirements. In addition, the following items should be presented for review at each PDR.

a. Preliminary Failure Modes and Effects Analyses

b. Design data analyses for integrated diagnostics, including requirements and preliminary design verification results

c. Maintenance concept for the portion of the system being reviewed and traceability to the system maintenance concept

d. Operational and maintenance functions

e. Allocation of qualitative and quantitative requirements

f. Criteria for support elements

g. Tradeoff studies

h. Cost/System Effectiveness Modeling and Life Cycle Cost Analysis

i. Preliminary Logistic Support Analysis, including LSAR data relating to maintenance, task analysis, maintenance concepts, and logistic resource requirements (e.g., support equipment, training equipment, personnel, tools)

j. Evaluation of alternatives

k. Test plans

l. Preliminary testability design analysis report, including preliminary inherent testability checklist and calculated inherent testability

4.1.4.6 Preliminary Design Reviews. Verify by inspection that the preliminary design review agenda contains items for reviewing the diagnostic capability of each CI.

Verification Rationale

Since diagnostics is an integral part of the system design process, the diagnostic capability review and evaluation is implicit in the PDR process and should be verified by inspecting the PDR agenda.

Verification Guidance

The PDR has been structured in MIL-STD-1521 to evaluate the progress, technical adequacy, and risk resolution of the selected design approach; to determine its compatibility with performance and engineering speciality requirements of hardware CIs development specification; and to establish the existence and compatibility of functional and physical interfaces among the CIs.The procedure containing the diagnostic-related times should be included as part of the PDR agenda submitted by the contractor for approval prior to the PDR.

3.1.4.7 Diagnostic detail design. Detailed diagnostic design shall be incorporated into the design of the system/CI.

Requirement Rationale

Diagnostic design is characterized by its interactive nature and a high degree of interdependence with the supportability engineering specialties (i.e., reliability, maintainability, integrated logistic support, testability, human engineering, and safety). The allocation of diagnostic resources must be based on inputs from these disciplines. The detail design phase synthesizes into the weapon system design the allocated baselines of the diagnostic design requirements that evolved as a result of the system, element, subsystem, and assembly preliminary designs.

Requirement Guidance

Detail Design Environments

The diagnostic detail design environment is an essential component of the overall diagnostic design activity, which has been established by the contractor in response to the SOW and specifications requirements. The environment encompasses both the implementation methodology and the specialty coordination associated with the diagnostic design process. Evidence of these should be evident in the products of the detail design effort.

Diagnostic Related Data Inputs

The data flow required to develop the composite diagnostic capability must be responsive to the diagnostic mix established for the specific system under consideration. Embedded diagnostic features, such as BIT, BITE, SIT, performance monitoring, status monitoring, embedded training, embedded maintenance aiding, adaptive AI-based diagnostic based systems, etc., are an integral part of the prime equipment detail design. For the external diagnostic elements, such as automatic test equipment and the associated test program sets, manual test equipment, portable maintenance aids, technical information (hard copy or electronic), the firm requirements for associated diagnostic data must flow from the preliminary design phase to the detail design phase. Inputs or information needs required to undertake diagnostic detail design include the following.

System/subsystem/assembly configuration item development specifications

System/subsystem/assembly software design documents

Preliminary interface design document

Test effectiveness data for GFE

Description of methodologies, models, and tools to be used in system effectiveness analysis for the detail design

Identification of failure modes and effects and failure rates for each item from Task 204 of MIL-STD-470A to be used to predict BIT, SIT and offline test effectiveness

Preliminary Testability Design Analysis Report

4.1.4.7 Diagnostic detail design. Verify that the incorporation of diagnostic capability is accomplished in a comprehensive, timely, efficient, and cost-effective manner by conducting in-process reviews.

Verification Rationale

In-process verification of the detail diagnostic design activity is the most effective methodology available for both automated and manual design environments. CI analyses, test, and evaluation efforts must address the total design which incorporates the functional, diagnostic maintainability, and reliability attributes necessary to meet specified requirements. A fragmented approach may permit a CI design to move forward, based on partial, inconclusive, and incomplete evaluation results.

Verification Guidance

The SOW would normally establish the formal (PDR and CDR) and informal (in-process) design review requirements. General guidance for diagnostics in-process reviews can be found in Task 102 of MIL-STD-2165.

Specific guidance for the in-process review activity should be developed by the contractor as part of the systems engineering and diagnostic planning activity. The selected review mechanisms will require tailoring to accommodate the automated and/or manual design environments employed.

In-process diagnostic design reviews should assess progress of the diagnostic design in greater detail than system program reviews. Ensure that the various contractor organizational elements that affect, or are affected by, diagnostic capability are represented and have an appropriate decision-making authority.

Detail diagnostic design guidelines and checklists need to be developed on the basis of guidance in MIL-STD-2165, Subtask 102.2.2, and Appendix A, 50.3, and the outputs of MIL-STD-1388-1, Task 205, Supportability and Supportability-Related Design Factors; MIL-STD-785, Task 204, Failure Modes, Effects, and Criticality Analysis; MIL-STD-470, Task 204, Failure Modes and Effects analysis--Maintainability Information, and Task 205, Maintainability Design Criteria.

3.1.4.7.1 Design embedded diagnostics capability. Embedded diagnostic detail design shall be performed for the system, segment, element, subsystem, and assembly.

Requirement Rationale

Diagnostic capability is achieved through the refinement and implementation of the diagnostics design techniques of the preliminary design.

Requirement Guidance

During diagnostic detail design, the diagnostic capability analyses and allocations performed during the preliminary design are further refined and synthesized into the segment, element, subsystem, and assembly designs. In particular, the following tradeoffs, analyses and considerations should be addressed.

1. Refinement of test design tradeoffs. The embedded diagnostics design may incorporate a mix of BIT, SIT, performance monitoring, and status monitoring that provide a level of diagnostic capability consistent with operational availability requirements, life cycle costs, and mission constraints. General guidance for BIT design is contained in AFSC-PAM 800-39, Built-in-Test Design Guide. Alternate diagnostic strategy designs should be analyzed and traded off against the requirements for performance, supportability, and cost to arrive at a configuration that best meets system needs. Analyses and trades that should be refined include the following.

   Analysis of BIT, SIT, performance monitoring, status monitoring, and offline test compatibility

   BIT vs. ATE tradeoffs for each maintenance level

2. General testability considerations. These considerations incorporate testability features in a system, element, assembly, or component design to enhance online and offline test. The testability requirements stated in MIL-STD-2165, Appendix A, shall be incorporated where applicable. The testability features include the following.

   Physical partitioning in a manner consistent with FD/FI objectives (i.e., I/O pin utilization to accommodate both functional I/O and test access requirements, digital only and analog only partitioning and localization of large fanouts to lowest CI level possible)

Functional partitioning to achieve straightforward fault isolation through either having single functions per CI or test independence of multiple functions within a CI

Electrical partitioning of complex functions to permit independent testing of a number of smaller subfunctions

Initialization capability to place CIs into a well-defined initial state or define the state of the CI sufficiently for an efficient start of the fault isolation

Test control for complex functions in order to achieve sufficient control of internal operation to facilitate detection and isolation of CI internal faults

Test access through test points, data paths, and circuitry to provide sufficient data for fault detection and isolation within the CI

3. Vertical testability concept. This concept addresses compatibility of testing among all levels of maintenance, including factory testing, and is key to minimizing CNDs and RTOKs. The core of this concept is twofold. The first is the establishment of a Cone of Tolerance among these levels. The second deals with the compatibility of environments under which these tests are performed. Implementation of the vertical testability requires the establishment of a "Cone of Tolerance" and specification of test conditions for all levels of design and maintenance. Establishment of the approach is part of Task 203.2.1 of MIL-STD-2165. Detailed guidance on implementing vertical testability and documenting the traceability of testing requirements and tolerances is described in Appendix G.

4. Test effectiveness measures. At the completion of the system, element, subsystem, and assembly designs, test sequences should be generated for each design and test effectiveness should be measured. The test effectiveness measures include functional coverage (an enumeration of which functions in an item are exercised by the test) and failure-based measures that include fault detection coverage, fault resolution, fault detection time, and fault isolation time. MIL-STD-2165, Appendix A, 50.7.3, provides guidance for measuring the test effectiveness.

Requirement Lessons Learned

To be effective and efficient, embedded diagnostics detail design must be integral to the detail design of the segments, elements, subsystems, assemblies, and components; and the test effectiveness of each design must be measured prior to the finalization of the detail design.

4.1.4.7.1 Design embedded diagnostic capability. Verify that the incorporation of the embedded diagnostic detail design is accomplished in a timely, efficient, and cost-effective manner by conducting in-process reviews.

Verification Rationale

In-process verification of the detail diagnostic design activity is the most effective methodology available for both automated and manual design environments. CI analyses, test, and evaluation efforts should address the total design that incorporates the functional, diagnostic, maintainability, and reliability attributes necessary to meet specified requirements. A fragmented approach may permit a CI design to move forward based on partial, inconclusive, or incomplete evaluation results.

APPENDIX A

Verification Guidance

Specific guidance for in-process reviews and CDRs should be developed by the contractor as part of the system engineering and diagnostic planning activity. The guidelines for the reviews should include verification of the results of the test effectiveness measures performed as part of the detail design in accordance with MIL-STD-2165, Appendix A, 50.7.3. Completion of inherent testability assessment (see 4.1.4.4) is required prior to CDR.

The embedded diagnostic detail design can be verified through the conduct of in-process reviews and CDRs to ensure that the diagnostic detail design solutions, as reflected in the draft CI product specifications, the Software Detailed Design Documents, Interface Design Documents, and engineering drawings satisfy the requirements established by the CI Development Specifications and the Software Preliminary Design Document. The diagnostic risks should also be reviewed on a technical, cost, and schedule basis.

3.1.4.7.2 Interface with engineering disciplines and logistics support. The interface with other disciplines, initiated during preliminary design, shall be continued to ensure the proper integration of diagnostic elements.

Requirement Rationale

A system diagnostic capability is the result of an iterative and phased design process that must maintain the interfacing with other disciplines that was established during preliminary design, to ensure continued compatibility during the detailed design phase.

Requirement Guidance

The disciplines related to the diagnostic design and requiring interfacing to ensure compatibility are the following.

1. Reliability

A number of significant interactions must take place between reliability and diagnostic activities to achieve an efficient, cost-effective design that meets system availability requirements.

Prioritization of the incorporation of BIT must be based on the initial failure rate estimates developed during the preliminary design effort. Also, reliability-critical items should be identified and included in the prioritization as early in the detail design process as possible (MIL-STD-785, Task 208).

Reliability estimates and modeling should incorporate factors that account for the increased component count associated with the incorporation of BIT/SIT hardware (MIL-STD-785, Tasks 201 and 203).

BIT/SIT implementation should be subjected to sneak circuit analysis to ensure that BIT/SIT failures do not induce additional failures and that fail-safe failure reporting logic is employed (MIL-STD-785, Task 205).

The reliability development/growth test program must include BIT/SIT functions to ensure that false alarms due to marginal BIT/SIT performance are addressed (MIL-STD-785, Task 302).

2. Maintainability

The following maintainability design criteria need to be considered in the design of the diagnostic capability including BIT/SIT functions (MIL-STD-470, Task 206).

Circuit design techniques for fault detection and isolation
Limitations of numbers and varieties of support equipments
Number of personnel and skill levels
Testability of parts, adjustments, and connections
Training requirements and needs
Inherent maintenance and maintainability characteristics of components to be used

The impact of the composite diagnostic capability must be considered in the following elements of the maintainability analysis, when appropriate (MIL-STD-470, Task 205).

Mean and maximum time(s) to repair at the appropriate maintenance level(s)
False alarm rates
Fraction of faults detected at the respective maintenance level(s)
Fraction of faults isolated at each maintenance level
Mix of diagnostic capability associated with each level of maintenance

3. Technical Information

Ensure that the content and organization of the technical/maintenance data to be developed adequately reflects the built-in and external diagnostic capabilities employed in the maintenance of the system. Sufficient detail regarding the operation of the diagnostic capability, correlation of failure reporting to malfunction symptoms, and maintenance alternatives to inconclusive FD/FI indications must be provided. The media on which the data is to be stored and made available to the maintenance personnel should be that most compatible and efficient in terms of the maintenance tasks. Consider electronic delivery systems and other associated data presentation systems.

4. Personnel and Training Requirements

Implement personnel and training requirements/allocations that were made prior to this task. Establish a training curriculum concurrently with the system detail design, addressing formal schooling, as well as on-the-job training. If electronic delivery of technical information is employed, consider combining training aids with the delivered technical information. Aiding and training are somewhat similar in nature and, at times, indistinguishable. The training curriculum should be aimed at the user(s) and accessed in a useful manner.

Training devices can be free-standing or embedded in the prime system. They can serve as maintenance training devices or can be incorporated with operational training. Separate and distinct training devices (maintenance trainers) may be required for formal schooling.

Human engineering principles should be applied to the diagnostic support hardware and software, in accordance with MIL-STD-1472. In summary, development and delivery of personnel and training curricula, hardware, and software should be accomplished concurrently with prime system development, test, and evaluation.

5. DT&E

Make provisions in the Test and Evaluation Master Plan for the DT&E of embedded and external diagnostic capability at the earliest possible point in the FSD Phase. Coordinate to ensure all elements required for a functioning diagnostic capability are available within the proper time frame. The decision to proceed with production should not be made without adequate confirmation of diagnostic performance.

6. Production Requirements

Ensure there is production test capability to verify the performance of built-in capability and that, once verified, the built-in diagnostic capability becomes an integral part of the subsequent performance verification process.

In addition, the development of factory test programs should not be undertaken independently of the target depot test equipment. The benefits of vertical test program commonality strongly weigh against committing to dissimilar test systems.

The Production Management Plan, which is prepared per AFSCP-800-3, documents plans for these production activities.

7. Data Collection and Maturation

Consider the maturation mechanisms and methodology that can be employed to select specific diagnostic implementation techniques. For example, performance limits can be established using either hardware or software control. The data requirements and revision mechanisms for each of these implementation alternatives differ; therefore, the data collection and diagnostic maturation planning must reflect these differences. Coordination between the implementation activity and the activity responsible for diagnostic maturation must take place to avoid a costly modifications approach to achieve the required diagnostic goals. The activities pertinent to production data collection should be documented in the Production Management Plan.

8. Offline Testing Requirements

Use procedures defined in the MATE Acquisition Handbook, Volume II, for establishing offline test requirements. These requirements will permit acquisition and development of the associated offline test equipment.

8.1 ATE Requirements

Determining what part of the diagnostic requirements for each maintenance level will be met with offline automatic test equipment depends upon the following factors.

System Maintenance Concept
BIT/Offline Test Tradeoffs
Logistic Support Analysis.

Apply these factors to identify the initial candidates for offline test and the associated ATE test requirements. Once these requirements have been established, procedures defined in the MATE Acquisition Handbook, Task 503 should be applied to determine the most effective ATE configuration.

The first step is to identify and review the requirements for offline ATE derived from the diagnostic allocation process.

The second step is to compare offline test requirements to inventoried MATE System capability and any other ATE that could be used in accordance with MATE Acquisition Handbook Task 502.

The third step is to apply the test effectiveness measures that were identified as part of the preliminary design activity to the designs that are offline test candidates for the level of maintenance under consideration.

The results of these steps must be analyzed for any shortfalls and the results fed back to the offline diagnostic allocation process. Upon completion of this iterative process, an ATE configuration capable of meeting the offline diagnostic requirement will have been identified.

8.2 TPS Requirements

Ensure the Test Program Set (TPS) implements the offline diagnostic capability identified through the detail diagnostic design activity (see MATE Acquisition Handbook, Task 651 (TPS)). TPS performance requirements must reflect offline test diagnostic requirements, such as fault coverage, fault isolation ambiguity group size, and time to fault isolate. The feasibility of meeting these requirements should be substantiated by the inherent testability analysis and test effectiveness assessment performed as part of the preliminary diagnostic design activities.

See Appendix H, 90.4, for matrices that relate the ID process described in this standard to relevant logistic support and engineering disciplines.

Requirement Lessons Learned

Designs employing after-the-fact incorporation of diagnostic capability generally are more complex and perform poorly as compared to comparable CIs for which the diagnostic design was performed concurrently. Both schedule and cost may be adversely affected by an after-the-fact incorporation of diagnostics.

4.1.4.7.2 Interface with engineering disciplines and logistic support. Verify that the interfacing tasks initiated during preliminary design are continued through detail design by conducting inspections and in-process reviews.

Verification Guidance

Verification should focus on how well the various elements of the diagnostic capability are integrated. Effective integration should consider both vertical and horizontal compatibility that supports a logical approach to the overall diagnostic capability. Figure 4 indicates the relationships between the horizontal elements (testing, technical information, and personnel and training) and the vertical elements (maintenance levels). Figure 4 can be expanded into matrices that are useful in verifying the integration of diagnostic elements. The matrices should be prepared for various design levels (system, subsystem, assembly, etc.). The matrices should be tailored to the specific weapon system and may be used in conjunction with data deliverables (e.g., test requirements document).

Vertical testability verification procedures are addressed in Appendix G.

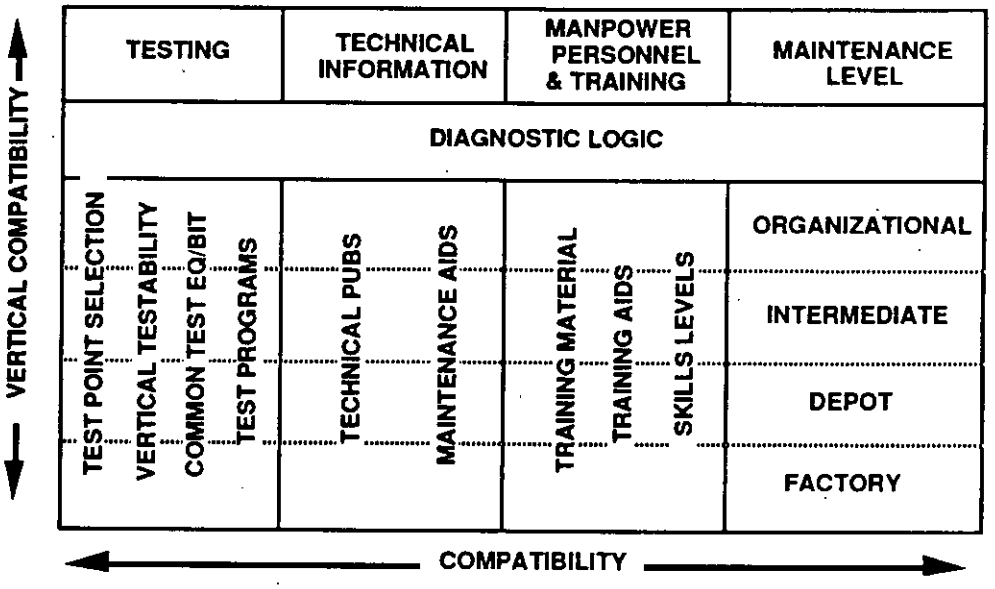

Figure 4 Integration of Diagnostic Capability

3.1.4.7.3 Diagnostic inputs to hardware and software specifications. Diagnostic segments shall be developed and included in the appropriate hardware and software draft product specifications.

Requirement Rationale

The efforts of the detail design are documented in specifications, drawings, schematics, and other documentation. To ensure that the designed diagnostic capability will be used during fabrication, the diagnostic capability must be incorporated into the appropriate draft product specifications.

Requirement Guidance

Guidance for incorporating diagnostic capability into specifications is included in AFGS-87256, 3.

4.1.4.7.3 Diagnostic input to hardware and software specifications. Verify that the results of the diagnostics detail design are documented in the revised versions of the appropriate development specifications by inspecting the specifications.

Verification Guidance

See AFGS-87256, 4.0.

3.1.4.8 Diagnostic related plans. The contractor shall address relevant portions of the integrated diagnostic process and the development of the diagnostic capability in appropriate management plans.

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Requirement Rationale

Prior to fabricating the prototype/first article, planning documents must be reviewed and updated to ensure development of diagnostic capability is adequately managed.

Requirement Guidance

See 3.1.3.3.

Requirement Lessons Learned

See 3.1.3.3.

4.1.4.8 Diagnostic related plans. Verify that the integrated diagnostic process has been incorporated into the SEMP and into other relevant plans by evaluating these documents.

Verification Guidance

See 4.1.3.3.

Verification Lessons Learned

See 4.1.3.3.

3.1.4.8.1 Update diagnostic inputs to the Test And Evaluation Master Plan. Diagnostic input to the Test And Evaluation Master Plan (TEMP) must be updated.

Requirement Rationale

Test and evaluation is an essential part of the diagnostic capability maturation process. During the later stages of FSD, prior to production, verification of the diagnostic design becomes critical. Therefore, diagnostic issues must be addressed in the TEMP.

Requirement Guidance

DoD Directive 5000.3 requires the preparation of a TEMP. This directive is amplified by AFR-80-14, Research and Development Test and Evaluation. The TEMP is the basic planning document for all test and evaluation related to a particular system acquisition. During FSD final test and evaluation plans for DT&E and OT&E are made.

DoD Directive 5000.3-M-1 contains the guidelines for the preparation of the TEMP. Chapter two contains the format for the TEMP in which Part III related to DT&E and Part IV deals with OT&E. Each of these parts deals with a significant number of diagnostic issues, such as reliability, maintainability, logistics, safety, software, and training. Care should be exercised, especially, at OT&E to ensure that the entire diagnostic capability will be evaluated. Output from MIL-STD 1388-1, Tasks 501.2.2 through 501.2.4, should be used as inputs to revise the TEMP.

Emphasis should be placed on ensuring that the entire diagnostic capability will be evaluated during OT&E and that an interface with maturation of this capability is established.

APPENDIX A

Requirement Lessons Learned

One of the major lessons learned in the acquisition of presently deployed aircraft is that test and evaluation of the entire diagnostic capability must be undertaken at OT&E. The updating of the TEMP during each phase of the weapon system acquisition ensures that the contractor and Air Force will understand that test and evaluation of diagnostic capability will be an important factor. Thus, attention will be given to the timely development of the entire diagnostic capability.

4.1.4.8.1 Update diagnostic inputs to the Test And Evaluation Master Plan. Verify by inspection that diagnostic inputs have been made to the TEMP.

Verification Rationale

Inspection of this plan is the only method available to verify its validity.

Verification Guidance

Utilize DoD Directive 5000.3-M-1 and the following checklist to verify the adequacy of the TEMP.

1. Have diagnostic-related inputs to the TEMP been included?
2. Have final plans been made for DT&E and OT&E?
3. Has emphasis been placed on evaluation of the entire diagnostic capability?
4. Is there a logical relationship between the TEMP and the diagnostic maturation program plan?

Verification Lessons Learned

Without proper verification of the TEMP, there is considerable doubt that diagnostics test and evaluation will occur in a timely and effective manner.

3.1.4.9 Update diagnostic inputs to the System Operational Requirements Document and the Requirements Correlation Matrix. Diagnostic inputs to the System Operational Requirements Document (SORD) and the Requirements Correlation Matrix (RCM) shall be updated.

Requirement Rationale

The SORD is the requirements and planning document that addresses operational and support needs. It amplifies and refines the SON. The SORD and its attached Requirements Correlation Matrix (RCM) document and track the goals and requirements that influence the design of the diagnostic capability. Therefore, diagnostic inputs to the SORD and RCM must be updated to document additional quantitative and qualitative factors relating to diagnostic performance requirements and to provide for easy comparison and correlation of requirements to specifications and to test criteria.

APPENDIX A

Requirements Guidance

Use AFR-57-1, Operational Needs, Requirements, and Concepts , as a guide. An RCM is attached to the SORD. Formats for both the SORD and the RCM are included in AFR-57-1. The RCM lists parameters and requirements that the system must have to accomplish its intended mission and is used to document and track the formulation of and changes to these user requirements as they evolve through the program acquisition process.

Attachment 6 to AFR-57-1 provides the format for the SORD. The content of the SORD evolves with the design of the weapon system. Inputs relative to the system's diagnostic capability should be reflected throughout the SORD. Particular attention should be paid to the paragraph dealing with combat or mission reliability and maintainability. This paragraph discusses the need for different performance capabilities, depending on mission profiles and environmental conditions. These performance capabilities are some of the major requirements that influence the design of the diagnostic capability.

The format for the RCM is contained in Attachment 8 to AFR-57-1. The RCM contains both requirements and goals, which become requirements as the design of the weapon system progresses. The RCM is a key part of the diagnostic maturation process (see Appendix C). Updates to the SORD and RCM should be based on the results of tradeoffs and analyses that define diagnostic

Update SORD diagnostic inputs with two concerns. First, address the general concepts and needs that will be expanded or clarified by the RCM parameters. Second, avoid specifying diagnostic-only requirements until trades or analyses have been made to determine values that best support operational needs. Appendix E, 60.2, lists operational parameters along with their diagnostic impact. This appendix section should aid in updating diagnostic statements for the SORD.

Requirement Lessons Learned

Improper attention paid to establishing and tracking diagnostic requirements in the SORD and RCM, in most cases, will lead to unsatisfactory performance of the diagnostic capability and a waste of manpower and dollars.

4.1.4.9 Update diagnostics inputs to the System Operational Requirements Document and the Requirements Correlation Matrix. Verify that appropriate updating of diagnostic inputs are included by inspecting the SORD and RCM.

Verification Rationale

Inspection is the most effective verification method as guidance is included in AFR-57-1 and the following checklist.

Verification Guidance

Inspection of inputs to the SORD/RCM should be the responsibility of the implementing command. Guidance in AFR-57-1 should be followed in addition to the following checklist .

1. Are diagnostic requirements based on mission needs and operational constraints?

2. Are diagnostic issues, goals, and requirements reflected throughout the SORD for all elements that make up the diagnostic capability?

3. Has the concept of diagnostic growth been included?

Verification Lessons Learned

Establishment of inadequate or inappropriate diagnostic requirements often result in an inadequate diagnostic capability.

3.1.4.9.1 Update diagnostic inputs to the Depot Support Requirements Document. Diagnostic inputs to the Depot Support Requirements Document (DSRD) shall be updated.

Requirement Rationale

The DSRD is the planning document for depot support. It supports the SON and the SORD. Updating of the diagnostic inputs to the DSRD must be provided to assure the plans and requirements for providing both Depot maintenance and material support are adequate.

Requirement Guidance

Use AFR-57-1, Operational Needs, Requirements, and Concepts, as a guide. The DSRD is prepared and issued in parallel with the SORD. Attachment 9 to AFR-57-1 is the format for preparation of the DSRD. The content of the DSRD evolves with the design of the weapon system. The initial version is required at Milestone I. Inputs relative to the system's diagnostic capability should be reflected throughout the DSRD for all diagnostic elements used in the depot. Particular attention should be paid to the concept of vertical testability that, at depot level, promises the use of common ATE with that used at other maintenance levels. This topic should be addressed under the MATE section of the DSRD (Section 2d of Attachment 9 to AFR-57-1).

Requirement Lessons Learned

Improper attention paid to early planning for depot support can result in lengthy and costly periods for transitioning from contractor to Air Force support.

4.1.4.9.1 Update diagnostic inputs to the Depot Support Requirements Document. Verify that appropriate updates of diagnostic inputs are included by inspecting the DSRD.

Verification Rationale

Inspection is the most effective verification method since guidance is provided in AFR-57-1 and the following checklist .

Verification Guidance

Verification is achieved by inspection and analysis of inputs to the DSRD by responsible persons. This verification should be the responsibility of the implementing command. Guidance in AFR-57-1 should be followed. In addition, the following checklist should be used.

1. Have vertical testability requirements been incorporated?

2. Have the diagnostic elements that compose the diagnostic capability been integrated?

3.1.4.10 Critical Design Review. The final design review shall ensure that all diagnostic requirements have been addressed prior to fabrication.

Requirement Rationale

Fabrication/coding of the CI (hardware and software) is initiated upon completion and approval of the CDR results. Detail design, as disclosed by the draft product specification, must be reviewed for its compliance with diagnostic capability before the diagnostic elements fabrication/coding is initiated.

Requirement Guidance

MIL-STD-1521 contains procedural guidance. The CDR shall be conducted on each configuration item prior to fabrication/production/coding release to ensure that the detail design solutions, as reflected in the Draft Hardware Product Specification, Software Detail Design Document , Database Design Document(s), Interface Design Document(s), and engineering drawings, satisfy requirements established by the Hardware Development Specification and Software Top-Level Design Document. The CDR shall be held after the Computer Software Operator's Manual, Software User's Manual, Computer System Diagnostic Manual, Software Programmer's Manual, and Firmware Support Manual have been updated or newly released.

Each CDR should provide as much ensurance as practicable that all diagnostic requirements are satisfied. The following data should be presented as an extension of the information presented at the PDR.

a. Detailed analyses that identify the extent to which BIT/SIT detect and isolate faults and that identify those failures that will require SE or manual methods to detect or isolate

b. Diagnostic allocations in Part II CI specifications to the LRU and SRU level (Traceability of these allocations to the Part I CI system specification should be demonstrated. Flexibility to re-accomplish diagnostic allocations until product baseline is established at PCA should be provided.)

c. Definition of the maintenance plan/concept for the CI, together with supporting LSA documentation, including support requirement and level-of-repair analysis results (Logistic simulation results should be presented to substantiate the plan/concept.)

d. Presentation of testability analysis/assessment results for the CI design to substantiate the fault detection/fault isolation analysis (Tasks 202 and 203 of MIL-STD-2165)

e. Appropriate updates to the items reviewed during the PDR

Further guidance on the review of diagnostic issues is included in the following.

MIL-STD-499, 5.2	Engineering Management
MIL-STD-1388-1, Task 103.2.2	Design Reviews
MIL-STD-785, Task 103.2.2(b)	CDR
MIL-STD-470, Task 103.2.2(b)	CDR
MIL-STD-2165, Task 102	Testability Reviews
DoD-STD-2167, 5.8.1.3	Formal Reviews

4.1.4.10 Critical Design Review. Verify that the detail design of the system CIs is evaluated for their specified diagnostic capability during the CDR.

Verification Guidance

The procedure containing the diagnostics-related items is included as part of the CDR agenda submitted by the contractor for approval prior to the CDR. See 3.1.4.4.10 for a checklist.

3.1.4.10.1 Diagnostic segments of the Test Requirements Review. The developer's readiness to begin diagnostic element-related CSCI testing shall be determined.

Requirement Rationale

The diagnostic segment of the TRR consists of a review of each diagnostic-related CSCI to determine whether the software test procedures are complete and to ensure that the contractor is prepared for formal CSCI testing.

Requirement Guidance

The diagnostic segment of the system/CI TRR(s) shall be a formal review of the contractor's readiness to begin formal diagnostic-related CSCI testing. The review is conducted after the software test procedures are available for diagnostic-related CSCI, such as CI BIT, System BIT and SIT, and after computer system component (CSC) integration testing is complete.

The items to be reviewed include the following.

1. Requirement Changes. Any changes to BIT, SIT, or testability requirements contained in the system/CI Software Requirement Specification or Interface Requirements Specification that have not been approved and which impact CSCI testing.

2. Design Changes. Any changes made to the BIT, SIT, or testability design parameters contained in the Software Top-Level Design Document Software Detail Design Document, Interface Design Document(s), since the PDR and CDR, which impact CSCI testing.

3. Software Test Plans and Descriptions. Any changes to the embedded diagnostic element portion of the approved Software Test Plans and Software Test Descriptions.

4. Software Test Procedures. Test procedures to be used in conducting BIT and/or SIT test effectiveness validation as part of the CSCI testing, including retest procedures for test anomalies and corrections.

5. Integration Test Cases, Procedures, and Results. Any embedded diagnostic element CSC (e.g., BIT components, SIT components) integration test cases, and procedures used in conducting informal diagnostic element CSD integration tests and the test results.

6. Software Test Resources Status of any software test resources that are required specifically for embedded diagnostic element CSCI testing. Such resources may include diagnostic test personnel and supporting test software and materials, including software test tool qualification and review of the traceability between requirements and their associated tests.

7. Test Limitation. Identification of all software test limitations associated with embedded diagnostic element CSCI/CSC testing.

8. Software Problems. Status of the embedded diagnostic element's software problems, including all known discrepancies of the CSCI and test support software.

9. Schedules. Schedules for the remaining embedded diagnostic element software milestones.

4.1.4.10.1 Diagnostic segments of the Test Requirements Review. Verify that the system test documentation and specifications are current, technically accurate, compatible, and consistent prior to development and fabrication of diagnostic elements through review of test requirements.

Verification Guidance

Reviews must be conducted as a single review, not a number of reviews that are conducted in parallel (e.g., logistics, maintainability, prime system). Integration of diagnostics mandates integration of reviews.

MIL-STD-1521 provides the framework for a checklist and guidance to be used. Diagnostic items should be added to define diagnostic test requirements. (See 3.1.4.4.)

3.1.4.11 Fabricate and provide external diagnostic elements. External diagnostic elements shall be fabricated and provided to comply with specified requirements.

Requirement Rationale

After final requirements for the external diagnostic elements have been established, it is necessary to fabricate these elements so that they meet requirements in an effective and efficient manner.

Requirement Guidance

See guidance in 3.1.4.11.1 through 3.1.4.11.4.

4.1.4.11 Fabricate and provide external diagnostic elements. Verify development of maintenance diagnostic elements and the support infrastructure by reviewing fabrication process.

Verification Guidance

Develop a checklist to ensure that both the online and offline diagnostic systems are properly developed.

3.1.4.11.1 Offline testing capability. Offline testing capability shall be fabricated.

Requirement Rationale

At the completion of the system/CIs CDRs, the offline testing capability must be fabricated to provide an offline testing capability for the system/CIs that is timely and effective.

APPENDIX A

Requirement Guidance

The offline testing requirements may be manual or automatic. The requirements are determined from the following system/CI analyses, trades, and documents.

1. Repair Level Analysis (RLA). Defines the system indenture level (subsystem, LRU, SRU) test at designated maintenance levels (Operational, Intermediate, Depot).

2. Logistic Support Analysis Record (LSAR). Identifies testing performance requirements and identifies suitable existing test equipment (manual or automatic).

3. Support Equipment Plan (SEP). Identifies the quantity, schedule, and funding requirements for test equipment.

4. Support Equipment Requirements Data (SERD). Defines the test equipment requirements and is the document that initiates the test equipment acquisition.

5. Test Requirements document (TRD). Defines testing performance requirements in terms of UUT stimuli and measurement requirements.

The process for ATE and TPS requirements definition, acquisition, development, production, and deployment is delineated in the MATE System. ATE fabrication is covered by MATE Acquisition Handbook, Tasks 610 (ATE) through 620 (ATE). TPS generation is covered by MATE Acquisition Handbook, Tasks 658 through 666 (TPS). In accordance with AFSC/AFLC R 800-23, the program offices are responsible for the implementation of the MATE System in order to provide automatic testing support for systems/equipment.

4.1.4.11.1 Offline testing capability. Verify the fabrication of offline testing capability by reviewing data and tools employed.

Verification Guidance

Review the specifications, data, and MATE tools employed in fabricating the offline testing capability. Requisite to accurate verification is full disclosure of prime system design/development data.

3.1.4.11.2 Technical information delivery systems. Technical information delivery systems shall be defined, developed, and fabricated as part of the external diagnostic capability.

Requirement Rationale

There is a need to present technical information and troubleshooting advice to the technician on location and readily available for use. The technical information delivery system (TIDS), sometimes called job performance aid, provides such information.

Requirement Guidance

The TIDS provides the following.

Historical information on what fault was found in previous symptoms of a given nature.
Troubleshooting logic to assist in finding the fault.
Procedural information that assists the technician in finding and correcting a failure (eg. diagnostic procedures, functional descriptions, interface and interconnect information)

Normally, a TIDS is used in conjunction with a testing capability. TIDSs could be paper-based or could employ electronic delivery systems.

Electronic delivery promises to solve some of the problems associated with paper TIDS. Two attributes of electronic delivery systems are discussed below.

Information can be available to the technician in a matter of seconds by carefully constructed menus, in lieu of having to page through a paper document.

The collection of historical data and subsequent modification to the software programs that deliver technical information can be accomplished in a matter of seconds, instead of a in matter of months.

This latter attribute lends itself to the introduction of expert systems. The expert system can combine various pieces of information to lead the technician to a logical decision on what is faulty and how it can be repaired.

Essentially, there are two types of expert systems. The first deals with model-based diagnostics. It solves diagnostic problems by reasoning from a device model, which is a symbolic representation of components that constitute a device, together with their input/output behavior and interconnections. The other type is symptom-based diagnostics. Diagnostic problems are solved by manipulating a set of associations between symptoms and faults. Generally, the associations in the symptom-based approach are founded on simple, empirical observations, but there may also be logical consequences deduced from a device model of the system under test. Probably a hybrid model, which employs both approaches, is the more cost-effective approach.

An important aspect of the TIDS is its ability to train technicians on the job. Thus, training programs must be closely associated with the design and development of a TIDS.

During the mid-80s, such programs as the Integrated Maintenance Information System (IMIS), sponsored by the Air Force Human Resources Laboratory at Wright-Patterson Air Force Base, are in the process of developing specifications, standards, and guidance on the development and acquisition of TIDS.

A few facts should be remembered when applying TIDS and expert systems.

TIDS must be designed in conjunction with the user. Once a working model of the equipment is available, there should be a dynamic interchange of information between the maintenance technician and the design engineer.

User acceptance and adoption of TIDS will be facilitated when potential users are given a trial period in which to become familiar with these devices.

A system must be devised to ensure timely updating of information to correct errors and to add newly acquired information.

Requirement Lessons Learned

The Failure Reporting Manual/Failure Isolation Manual (FRM/FIM) concept is a paper form of TIDS that has been applied to both the F-15 and F-16. When the air crew reports a malfunction during debriefings, the FRM provides logic to bridge the gap between the air crew and

the maintainer. Together they use the FRM logic to develop a fault code that describes the malfunction in standard terms. This fault code leads the maintainer to the proper troubleshooting logic tree in the FIM. Problems were found with this concept. The fault isolation logic trees were sometimes inadequate or erroneous. Although these problem areas were identified, the documents were not updated as the system matured, thus making them less useful.

4.1.4.11.2 Technical information delivery systems. Verify that technical information delivery systems meet their intended function by reviewing development specifications.

Verification Guidance

Verification is difficult because of the lack of available specifications, standards, and guidance. Verification can be achieved by ensuring that a development specification has been prepared and reviewed for its adequacy. Final verification is achieved when the entire diagnostic capability undergoes IOT&E. Maturation of the software program is essential.

Verification Lessons Learned

Absence of verification can lead to inadequate software and hardware being deployed, such as the FRM/FIM deployed for the F-15 and F-16.

3.1.4.11.3 Training. Training curriculum and training devices shall be developed concurrently with the prime system fabrication.

Requirement Rationale

Guidance is required to ensure that weapon system developers pay adequate attention to satisfying training requirements for diagnostics.

Requirement Guidance

Prior to this requirement, personnel and training allocations have been made. This requirement involves implementing these allocations. The skill levels and quantity of technicians allocated should be considered when developing diagnostic hardware and software. The training curriculum should be established concurrently with the system fabrication. This includes the formal schooling curriculum as well as on-the-job training. If electronic delivery of technical information is employed, consider combining training aids with the delivered technical information as aiding and training are somewhat similar in nature. The training curriculum should be aimed at the user and accessible to a variety of users.

These training devices can be freestanding or embedded in the prime system. They can serve as maintenance training devices or they can be incorporated with operational training. Separate and distinct training devices (maintenance trainers) may be required for formal schooling.

4.1.4.11.3 Training. Verify that training requirements are satisfied in the fabrication of the prime system through review and evaluation.

Verification Guidance

Verification criteria are in the following MIL-STDs and MIL-SPECs.

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MIL-STD-1388-1	Logistic Support Analysis, Task 303.2.6
MIL-STD-2165	Testability Program for Electronic Systems and Equipments, 201.2.4c

3.1.4.11.4 Diagnostic requirements for technical information. Succinct, accurate, and timely information shall be provided for the maintenance technician.

Requirement Rationale

Avoid expensive, voluminous, inaccurate, and untimely delivery of technical orders by generating technical information in a form that is easily accessible, understandable, and revised. These deficiencies are described in the DoD Audit Report No. 87-115, of April 3, 1987, "Summary Report on the Defense-Wide Audit on Acquisition of Technical Manuals and Related Data From Contractors."

Requirement Guidance

Previously, there has been no firm guidance furnished by the Air Force relative to innovative means for generating and delivering technical information. It is necessary to seek ways to generate and deliver this technical information in a less costly manner without compromising its quality. There are a number of tools available, or under development, which can assist the designer of technical information in authoring the text when electronic delivery of technical information is contemplated. Guidelines and standards for automatic generation of technical information and its delivery electronically can be obtained from the Human Resources Laboratory at Wright-Patterson Air Force Base. This guidance information has been developed under the Integrated Maintenance Information System (IMIS) Program.

Innovative ideas for displaying this technical information are encouraged, as stipulated in Task 303, MIL-STD-1388-1. Care should be taken to provide quick access to the required data. For electronic delivery of this data, formats may vary substantially from paper-based technical orders. Previous specified access times and information modification times should influence the type of generation and delivery methods. DoD INST 4151.9 requires the services to plan and schedule the acquisition of technical manuals (technical information) to ensure their availability in final form before, or concurrently with, delivery of the system to the field. During design, final plans should be developed along with the support equipment.

4.1.4.11.4 Diagnostic requirements for technical information. Verify diagnostic requirements for technical information through analysis.

Verification Rationale

Analysis is required to verify that the criteria established under this task and controlled by the appropriate military standards have been met.

Verification Guidance

Criteria for verification is in two military standards.

MIL-STD-1685 (SH)	Comprehensibility Standards for Technical Manuals (Metric)
MIL-STD-1752 (USAF)	Reading Level Requirements for Preparation of Technical Orders.

If electronic delivery of technical information is employed, the format and content may be modified.

Standards for the electronic delivery of technical information are contained in MIL-STD-1472, Human Engineering Design Criteria for Military Systems, Equipment, and Facilities.

3.1.4.12 Diagnostic segment of Development Test and Evaluation. The diagnostic capability shall be tested and evaluated during detail design.

Requirement Rationale

The DT&E assists the diagnostic design and development process by providing feedback to the integrated diagnostics activities in progress. This feedback helps the diagnostic design mature.

Requirement Guidance

DT&E may be performed throughout the development of the system. However, sufficient diagnostics DT&E must be accomplished before the Milestone III decision to proceed to production to ensure that the major diagnostic requirements for the FSD Phase have been met.

Perform diagnostics DT&E in accordance with T&E plans for diagnostics contained in the PMP, Section 5, and in the TEMP. Guidance information is contained in applicable policy documents, including the following.

DoDD 5000.3	Test and Evaluation
AFR 80-14	Research and Development Test and Evaluation
AFSCP 800-3	A Guide to Program Management

The major approaches of DT&E for diagnostic include the following.

Proceed in phase with system and support equipment development, so that BIT is tested and evaluated concurrently with system performance; BIT and SIT are tested and evaluated concurrently with subsystem integration and system testing; and system integration and flight safety testing are concurrent with diagnostic testing of BIT and SIT features.

Implement the Diagnostics Maturation Plan so that deficiencies, ambiguities, and additional failure modes identified during DT&E are recorded in a timely manner to ensure traceability and appropriate corrections are made to the integrated diagnostic procedures.

Evaluate embedded diagnostic design as a separate entity in order to ensure it has been incorporated adequately as part of the system design.

Evaluate the diagnostic capability in selected critical areas of system design using fault evaluation.

Analyze the system design hierarchy of test tolerances (e.g., between system BIT and LRU/SRU level of BIT) to minimize false alarms.

Complete feasibility DT&E on prototype and preproduction units to assess technical risks and develop solutions to deficiencies.

During FSD, specific diagnostic capability segments of DT&E effort include the following requirements.

When available, ATE shall be evaluated for initial use supporting build and checkout of flight test aircraft. Manual procedures and associated operational prototypes shall be developed for support of flight test activities.

Engineering evaluation of the diagnostic elements capability at subsystem and system levels shall be conducted in concert with system integration testing activities, including evaluation tests in the engineering laboratory and system integration test facilities.

Effective development of a diagnostic capability requires that testing of diagnostic capabilities proceed concurrently with prime and support equipment development. The object of the following diagnostics testing approach is to provide a viable diagnostic capability for use in support of flight and operational testing activities to provide for early maturation of the diagnostic capability. It should also be a program objective to validate the diagnostic capability, as well as the initial reliability and maintainability requirements, before production.

During early equipment development tests, built-in test features should be tested and evaluated concurrently with equipment performance testing. BIT performance is just as important to overall weapon system performance as the usually emphasized aspects of equipment performance. Simulated equipment failures should be used to assist in BIT testing and evaluations.

As equipment progresses to subsystem integration and performance testing, BIT and SIT features should be concurrently tested, evaluated, and corrected. Simulated equipment failures should again be used for BIT/SIT testing and evaluation.

System integration and safe-for-flight testing of equipment should include diagnostic testing of BIT and SIT features to ensure that this capability is ready for flight test support. Concurrently, organizational level support equipment required for diagnostic support should be tested to enable its use in the flight test program, together with preliminary T.O.s, which will evolve into final T.O.s for initial OT&E. Simulation of equipment failures to evaluate diagnostic capabilities should be included in this testing effort.

Qualification testing of both prime and support equipment shall include validation of diagnostic capability, which is a required aspect of both equipment and system performance. Simulated equipment failures should be included in the diagnostic validation test program. Evaluation of BIT/SIT should also be conducted during environmental extreme testing of the prime equipment and support equipment to ensure its proper functioning throughout the required equipment performance envelope.

Further procedures and guidance on the interface of DT&E activities with other verification, demonstration, and evaluation activity is contained in Appendix D, 50.4.

4.1.4.12 Diagnostic segment of Development Test and Evaluation. Verify that diagnostics DT&E testing and engineering analysis functions have been adequately and definitively performed through checklist evaluation.

Verification Guidance

Verification of diagnostics DT&E for a weapon system in development consists of many interrelated tasks performed in parallel with the diagnostics DT&E functions. A number of

techniques and methods will be used, dependent upon the specific test or engineering analysis being verified.

The starting point should be a verification baseline consisting of a checklist of diagnostics DT&E objectives related to the diagnostics-critical issues and diagnostics areas of risk. The objectives should be stated in terms of specific diagnostic engineering criteria for judging the system's performance.

Diagnostics DT&E data and results must be reviewed for completeness and soundness. Include correlation with data and results from prior diagnostics T&E to verify improved systems performance vs diagnostics DT&E objectives when diagnostic design corrections/updates are made.

3.1.4.13 Maintainability demonstrations. Diagnostics shall be incorporated into maintainability demonstrations.

Requirement Rationale

Maintainability demonstrations are required to verify the overall effectiveness of the diagnostic capability.

Requirement Guidance

Maintainability demonstrations are performed in accordance with the appropriate demonstration method contained in MIL-STD-471. Notice 2 of MIL-STD-471 contains requirements for demonstration and evaluation of system BIT/external test/testability attributes. This method should demonstrate the integration of the diagnostic capability for the system (e.g., integration of embedded test software and hardware techniques, automatic and manual test, BIT/SIT, training levels, human interface). The scope of the diagnostic portion of the maintainability demonstration includes the following.

1. Demonstration of testability parameters
   - BIT fault detection
   - BIT fault isolation time
   - BIT fault isolation level (ambiguity group)
   - BIT accuracy

2. Demonstration of Test Effectiveness (ATE)
   - ATE/TPS fault detection
   - ATE/TPS fault isolation time
   - ATE/TPS fault isolation level (ambiguity group)
   - UUT/ATE compatibility

3. Demonstration of technical information
   - Technical information access time
   - Technical information relative access ease
   - Technical information format
   - Technical information usability

4. Demonstration of training/skills
   - Relationship between maintenance procedures and skills
   - Relationship between formal training and actual maintenance job flow

5. Demonstration of vertical and horizontal compatibility
   Compatibility and consistency of test results between maintenance levels and their respective diagnostic elements.

An overall diagnostic capability results from the interplay of all the diagnostic elements that were used. A requirement should be established for early demonstration of this diagnostic capability so that the integration of all diagnostic elements can be assessed. This is referred to as a concurrent demonstration.

Further procedures and guidance on maintainability demonstrations and their interface with other test and evaluation activities is contained in Appendix D, 50.4.

4.1.4.13 Maintainability demonstrations. Verify by checklist evaluation of demonstration results that the diagnostics portion of the maintainability demonstration has provided a valid verification of the effectiveness of the diagnostic capability.

Verification Rationale

A checklist is the most effective way to verify this requirement.

Verification Guidance

The verification checklist may be derived by referring to the contents of the maintainability demonstration.

3.1.4.14 Diagnostic segment of Initial Operational Test and Evaluation. The overall effectiveness, operability, and suitability of the diagnostic capability shall be tested and evaluated.

Requirement Rationale

Evaluating diagnostic performance during Initial Operational Test and Evaluation (IOT&E) helps to determine diagnostic capabilities achieved and to identify any deficiencies in the diagnostic capability. Diagnostics IOT&E should focus on the integration of the planned diagnostic elements into a comprehensive, cohesive diagnostics subsystem.

Requirement Guidance

IOT&E must be accomplished prior to the Milestone III decision. Diagnostics IOT&E estimates the operational effectiveness and suitability of the system's integrated diagnostics design and procedures using test items representative of the expected production items.

Major approaches to diagnostics IOT&E include the following.

Testing in an environment as operationally realistic as possible

T & E initiating as early as possible during the FSD Phase

Testing for adherence to overall IOT&E objectives, with respect to diagnostics

Continued coordination with Diagnostics Maturation Program

Evaluation for 100 percent diagnostics testing

Further analysis of test tolerances related to the system hierarchy and embedded/external diagnostic procedures in order to minimize false alarms

Testing (particularly operational tests) and data collection should focus on the 100 percent diagnostics requirement. Testing and data collection should also evaluate the specified parameters, namely identification of critical failures, the false alarm rate, the percentage of faults detected and isolated automatically or manually, associated repair times, the unnecessary removal rate, consistency of test results, and the adequacy of personnel skills.

Use the diagnostic capability that is planned for field maintenance personnel whenever there is a need for system maintenance. This use of planned diagnostic capability applies to maintenance performed by either the contractor or the user. Contractors should use the diagnostic capability in acceptance and qualification tests and in the manufacturing and quality assurance process to the maximum extent possible. In addition to contributing to the maturation of the diagnostic capability, greater contractor use of diagnostics in these processes could result in production cost savings.

The diagnostic capability should be evaluated with respect to the Diagnostics Maturation Plan.

During IOT&E, system performance, operational suitability, and supportability factors are evaluated in an operationally realistic environment. There are two types of information that can be obtained for Diagnostics T&E: (1) faults within the system and how those faults were identified (diagnosed) and (2) faults/deficiencies within the diagnostic capability. For the latter, this includes evaluation of each element that contributed to the total diagnostic capability, as well as to the capability achieved by integration of the diagnostic elements. The former type of data can be obtained as a result of Reliability Growth Testing. The following specific information should be evaluated for each fault occurrence.

1. How did the failure manifest itself?
2. Was the manifestation due to stressing of the system beyond normal operational limits?
3. If a BIT alarm occurred, was it the result of a confirmed failure?
4. What techniques were used to isolate the fault?
5. How long did fault isolation take using those techniques?
6. Was the failure mission or operation critical?
7. Was the fault the result of a new or unplanned failure mode? Was BIT supposed to detect the failure? Did BIT detect the failure?
8. Is this failure mode expected to be encountered in the operational system?
9. Should provisions be included in the diagnostic capability to deal with this failure mode?
10. Will this provision involve a modification/addition to BIT, ATE, Manual Test Equipment, Maintenance Procedures, Skill Levels, Technical Data or TIDS?
11. Is an ECP required?
12. Is further investigation required?
    If yes - what plans have been made?
    If no - why not? (brief description)
13. Is correction of the diagnostic deficiency part of contractual requirements? Is it tied to incentive or warranty provisions?

Further procedures and guidance on the interface of OT&E activities with other verification, demonstration, and evaluation activities is contained in Appendix D, 50.4.

4.1.4.14 Diagnostic segment of Initial Operational Test and Evaluation. Verify by checklist evaluation that the diagnostic IOT&E have provided a valid estimate of the operational effectiveness and suitability of the diagnostic capability.

Verification Rationale

Verification by checklist is the favored method

Verification Guidance

The following is a checklist for verifications.

1. Are diagnostic IOT&E test articles sufficiently representative of the expected production items?
2. Is the diagnostic IOT&E environment as realistic as possible?
3. Do diagnostic IOT&E plans include evaluation for 100 percent diagnostic capability in selected critical areas?
4. Do IOT&E plans include analysis of test tolerances related to the system hierarchy and offline/online diagnostic procedures in order to minimize false areas?
5. Is diagnostic evaluation included in broad spectrum of IOT&E activities?
6. Is the scope of diagnostic IOT&E broad enough to do a preliminary evaluation of the fielded diagnostic capability?

3.1.4.15 Diagnostic input to Production Readiness Review. The Production Readiness Review (PRR) shall certify that the embedded diagnostic capability is ready for quantity production.

Requirement Rationale

A review is required to determine the status of specific diagnostic-related actions that must be accomplished prior to executing a production go-ahead decision.

Requirement Guidance

The PRR is accomplished incrementally during FSD, usually as two initial reviews and one final review to assess the risk in exercising the production go-ahead decision. In its earlier stages, the PRR concerns itself with gross-level manufacturing concerns, such as the need for identifying high-risk/low-yield manufacturing processes or the requirement for manufacturing development effort to satisfy design requirements. The embedded and external diagnostic elements shall be reviewed at the final PRR to ascertain the following.

1. Are the embedded diagnostic element designs ready for production?

2. Is the use of any of the external diagnostic elements (e.g., ATE) appropriate for the production testing environment?

4.1.4.15 Diagnostic input to Production Readiness Review. Verify by check list that the various diagnostic elements are ready for production.

Verification Rationale

Verification by checklist is the most effective method.

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Verification Guidance

Refer to the above checklist in the requirement guidance paragraph and the specific guidance given in AFSCR 84-2, Production Readiness Review.

3.1.4.16 Functional Configuration Audit. The Functional Configuration Audit (FCA) shall address the embedded diagnostic capability.

Requirement Rationale

The FCA is normally conducted on a prototype or preproduction item. The FCA certifies that the item meets its specified performance requirements and is ready for production and acceptance into Air Force Inventory. It is imperative that the diagnostic capability be checked against its specified performance requirements so that diagnostic deficiencies can be identified and corrected before the item proceeds into production.

Requirement Guidance

The diagnostic element-related test procedures shall be identified for inclusion in the contractor test plans, procedures, and test data that must be submitted by the contractor prior to the commencement of the FCA. The procedures for conducting an FCA are delineated in MIL-STD-1521.

4.1.4.16 Functional Configuration Audit. Verify that the diagnostic capability is validated prior to the production of applicable CI/CSCIs by reviewing applicable documents.

Verification Guidance

Review the test plans, procedures, and test results (submitted by the contractor prior to the FCA) for necessary diagnostic capability content and their implementation during the FCA.

3.2 PRODUCTION

3.2.1 Maturation inputs to production RFP. Inputs to the Production Phase RFP should be prepared relative to the maturation of the diagnostic capability.

Requirement Rationale

It is important to mature a weapon system's diagnostic capability during the Production Phase.

Requirement Guidance

The special Contracts Requirements Section (Section H) of the RFP should include the warranty requirements contained in the Weapon System Warranty Plan. This plan was developed during the DEM/VAL and FSD Phases and updated prior to issuing a production RFP. Guidance on the content of this plan is contained in the Weapon System Warranty Planning Guide," 1 March 1990, which is issued by the Product Performance Agreement Center (PPAC), ASD/ALTE. Diagnostic inputs to this plan are discussed in 3.1.4.2 of this appendix.

Sample inputs to the Production Phase SOW follow.

APPENDIX A

Diagnostic Maturation

The contractor shall mature the diagnostic capability in accordance with the established maturation plan. Ensure that required improvements are made to satisfy updated diagnostic specifications at each maintenance level. These improvements should include the following.

Maintaining and using the diagnostic data system to measure diagnostic performance and take required corrective action, in accordance with the warranty provisions contained in Section H of the RFP

Planning transition of the data analysis system to the Government

Demonstrating that the diagnostic capability satisfies the diagnostic requirements

CDRL Recommendations. The following is a list of recommended data deliverables to include in the CDRL.

1. External Diagnostic Demonstration Results (DI-R-71113)
2. Maturation Results (DI-R-7105)
3. Warranty Status Report (DI-A-1025)

4.2.1 Maturation inputs to production RFP. Verify adequacy and completeness of maturation inputs by inspecting the Production Phase RFP.

Verification Guidance

The following checklist may be used to ensure the contractor is required to perform the necessary maturation activities during production.

1. Are the warranty provisions, including remedies, contained in Section H of the RFP?

2. Have the provisions in the diagnostic maturation portion of the IDPP been incorporated into the SOW?

3.2.2 Diagnostic segment of Follow-on Operational Test and Evaluation. Diagnostic Follow-on Operational Test and Evaluation (FOT&E) shall verify that first article production items meet diagnostic requirements.

Requirement Rationale

FOT&E checks that the first article production items do not differ from preproduction units to such a degree that the desired capability is degraded. Diagnostic capabilities should be subject to this check.

Requirement Guidance

Perform diagnostic FOT&E in accordance with T&E plans for diagnostics contained in PMP Section 5 and the TEMP. Guidance is contained in applicable policy documents, including the following.

DoDD 5000.3	Test and Evaluation
AFR 80-14	Research and Development Test and Evaluation
AFSCP 800-3	A Guide to Program Management

4.2.2 Diagnostic segment of Follow-on Operational Test and Evaluation. Verify that the diagnostics FOT&E have validated the suitability of the diagnostic capability of the first production items of the system through checklist evaluation and testing.

Verification Guidance

The checklist employed as a verification baseline for diagnostics FOT&E should be similar to that used for diagnostics IOT&E except that the objectives listed (and related to the operational effectiveness and suitability requirements for the integrated diagnostics of the system) may be modified to accommodate diagnostics FOT&E.

Review diagnostics FOT&E data and results for completeness and soundness. Include correlation with data and results from prior T&E in order to verify improved system performance when diagnostic design corrections or updates are made. Tools and models should be developed to assist in verifying the effectiveness of diagnostic corrections and updates.

In central areas (e.g., where 100 percent diagnostic fault detection is mandatory), tests should be repeated for verification.

Verification Lessons Learned

Modification of the diagnostic capability after production has begun can increase the cost of modification significantly.

3.2.3 Diagnostic segments of Physical Configuration Audits. Requirements, guidance documents, and procedures to conduct Physical Configuration Audits (PCAs) shall be defined for the embedded diagnostic segments of configuration items.

Requirement Rationale

The PCAs of the configuration Items validate that the diagnostic element satisfies the hardware and software product specifications.

Requirement Guidance

The PCA is the formal examination of the as-built version of the diagnostic element against its design documentation. After successful completion of the audit, all subsequent changes to the diagnostic elements are processed by an engineering change action. The PCA also determines that the diagnostic element acceptance testing prescribed is adequate for acceptance of the production units by quality assurance activities. The procedures for conducting a PCA are contained in MIL-STD-1521, Appendix H. Sample PCA certification attachment checklists are contained in MIL-STD-1521, Appendix I.

4.2.3 Diagnostic segments of Physical Configuration Audits. Verify that the diagnostic segment of the PCA has been satisfactorily accomplished by reviewing the PCA agenda and related data.

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Verification Rationale

Review of the contractor-supplied agenda and data for the PCA, participation in the audit, and review of the minutes and the PCA certification checklist will verify the satisfactory audit of the diagnostic elements.

Verification Guidance

MIL-STD-1521, Appendix H, contains requirements for conducting this review.

Verification Lessons Learned

Without prior planning and identification of the requirements for validating the diagnostic elements during the audit, the diagnostic element, or portions of it, will not be audited, and deficiencies will not be discovered until production is started, or until the Configuration Item is deployed.

3.2.4 Diagnostic production data collection and maturation. Requirements established during the preproduction acquisition phases for diagnostic elements data collection and maturation shall be implemented during the Production Phase.

Requirement Rationale

Diagnostic maturation requires efforts in each acquisition phase that build upon the previous phase efforts.

Requirement Guidance

This task is divided into several subtasks to implement the diagnostic maturation mechanism. During the FSD Phase, a Production Management Plan (PMP), required by AFSCP-800-3 for the Production Phase of the prime system/subsystem/CIs, is developed. The production-pertinent requirements developed as part of the data collection and maturation activities, included in this appendix in the preproduction acquisition phases, should be included in the PMP. Before the start of production activities, review the plan to ensure that the diagnostic elements' requirements are included.

Additionally, the production acceptance test plans and test procedures shall contain plans and the procedures necessary to verify that the production units satisfy the specified diagnostic elements' parametric values. Diagnostic data collection is required for all acceptance test results (pass or fail).

4.2.4 Diagnostic production data collection and maturation. Verify by inspection that a diagnostic maturation program plan is continued during the production of the embedded diagnostic elements.

Verification Guidance

Before production go-ahead, inspect the PMP to determine its sufficiency for managing the diagnostic maturation during production. The following actions should be undertaken as part of the verification.

1. Inspect the production acceptance test plan for verification of diagnostic capability.

2. Inspect the production acceptance test procedures to ensure that the procedures are comprehensive enough to verify the diagnostic capability.

3. Develop a verification procedure tailored for the specific application and production facility that may include either resident Government personnel, contractor personnel, or a combination of both.

Verification Lessons Learned

Implementing the verification process is enhanced by using qualified Government or contractor quality assurance personnel.

3.2.4.1 Establish/update data sharing plans. The contractor shall establish and implement, or update, formal data sharing plans to ensure that functional organizations, team members, and subcontractors have access to current diagnostic development information throughout the production phase.

Requirement Rationale

Much of the technical data necessary to effectively develop and monitor integrated diagnostics in a system already exists within a contractor's facility and from user maintenance data. Some of this information, however, is not available to each group that is involved with the development or operation of the system. This information is either not distributed to the organizations that need it, is distributed too late to be of any practical use, or is not collected. Contractors that are involved in the defense business are typically subdivided into functional organizations with specific areas of responsibilities. Several of these organizations have an important part to play in developing, monitoring, maintaining, or redesigning (modifying) high quality diagnostics.

An effective means must be established to allow communication of iterative information between groups, contractors, and team members as the weapon system is produced and tested. Merely communicating necessary information within the company and among team members or vendors is not sufficient, however, unless it is done early and frequently in the production process. Otherwise, it becomes a documentation task rather than a sharing of information for the purpose of enhancing the design. Similarly, much of the information gathered on the user systems, such as CAMS, is hindered in its flow between units with the same weapon system, system managers, and other agencies by poor or non-existent data system interaction/networking, and must rely on tape, disk, or manual transfer of information.

Requirement Guidance

The acquisition agency should instruct the contractor to define/update and implement a formal data sharing plan (it can be part of the system engineering management plan or the IDPP). The plan should address the sharing of information used in the design of the weapon system and should be in operation prior to first production article acceptance by the user, even if that article is to be used for training purposes. Appendix F gives examples of the type of data elements and information required to perform diagnostic design activities during Production (data elements listed in Appendix F matrices applying to the Production Phase are those that reference 3.2.3.1 through 3.2.3.5). The plan should also address the interface with information regarding the performance of the diagnostic activity as it proceeds through demonstration, test and evaluation, and maturation. The plan should be required to include (1) information elements, (2) method of communication (hardware, software, languages, networking, network maintenance responsibilities), (3) sources of the information, (4)

expected users of the information, (5) method, frequency, and responsibilities of updating information contained in the data bank, and (6) security (classified, proprietary, limited access).

See 3.1.2.3.1 for further guidance.

Requirement Lessons Learned

See 3.1.2.3.1.

4.2.4.1 Establish/update data sharing plans. The formal data sharing plan and implementation shall be verified by inspection.

Verification Rationale

See 4.1.2.3.1.

Verification Guidance

See 4.1.2.3.1.

3.2.4.2 Update vertical test traceability matrix. Organizational, depot, and intermediate TRDs, including VTTM, that document test relationships between levels of test shall be updated.

Requirement Rationale

The data will ensure that each function is tested at each higher level of test. The data, in correlation with actual maintenance results, will be useful in solving CND/RTOK problems by providing traceability as to which tests are directly related at the different levels of test. Verification of vertical test compatibility can be accomplished by using the data to identify related faults at the different levels of maintenance. TPS qualification would be accomplished by inserting the same faults as inserted at maintainability demonstration.

Requirement Guidance

Vertical Testability, to ensure compatibility of testing among all levels of maintenance, including factory testing, is key to minimizing CNDs and RTOKs. The core of this concept is twofold. The first is the establishment of a Cone of Tolerance among these levels, and the second deals with the compatibility of environments under which these tests are performed. Implementation of the vertical testability requires the establishment of a "Cone of Tolerance" and specification of test conditions for all levels of design and maintenance. Establishment of the approach is part of Task 203.2.1 of MIL-STD-2165. Detailed guidance on implementing vertical testability and documenting the traceability of testing requirements and tolerances is described in Appendix G.

Requirement Lessons Learned

The F-16 Central Air Data Computer (CADC), Inertial Navigation Unit (INU), and the Low Power Radio Frequency (LPRF) LRUs have experienced CND/RTOK problems. It is believed that vertical test incompatibilities are a contributor to some of these problems. Vertical test traceability matrix data was compiled as a tool to isolate and solve these problems. During compilation of this data, it was discovered that formal documentation concerning the CADC

and INU BIT did not exist. If the BIT is properly documented, as well as the vertical test relationships between levels of test, CND/RTOK problems would be fewer and more easily isolated.

4.2.4.2 Update vertical test traceability matrix. Verification is accomplished by analysis and formal demonstration.

Verification Rationale

Verification would be accomplished by both analysis and formal demonstration. Analysis would show that each test was documented properly. M-demo and TPS qualification demonstration would demonstrate the accuracy of the data.

Verification Guidance

The data analysis would be accomplished by comparing the BIT data with actual BIT operation and the intermediate and depot level TPSs with the corresponding TRDs. The analysis would also verify that each lower level test has related test(s) at each higher level of maintenance. This would verify the linking table data. The formal demonstration would be accomplished by inserting faults at TPS qualification that are the same as those inserted at the maintainability demonstration to verify the failures as those predicted by the data.

3.2.4.3 Diagnostic performance assessment and evaluation. Performance of the diagnostic elements on the production line shall be assessed and evaluated, and needed corrective action shall be defined.

Requirement Rationale

Production test results can provide data to assess the performance of each element of the diagnostic capability, so necessary corrective actions can be identified.

Requirement Guidance

The production acceptance test results must be analyzed to assess the following.

1. Diagnostic element performance acceptance
2. Diagnostic element performance deficiencies

If diagnostic element performance deficiencies are found, the cause of these deficiencies must be determined through analysis of the acceptance test results. The following are common causes.

From a system perspective

SIT design
Embedded status monitoring design
Unachievable specified diagnostic parametric values
Integration of the specified diagnostic subsystem/CIs causes diagnostic values specified for various system levels to be incompatible
Previously undefined failure modes

From a subsystem/CI perspective

Subsystem/CI design
Subsystem/CI BIT design
Subsystem/CI interfaces design
Previously undefined failure modes

From a production test perspective

The test equipment design
Test equipment/UUT interface incompatibility
Test program performance deficiency
Test program/UUT incompatibilities
Acceptance test procedures

From a production management perspective

Manufacturing methods
Incoming inspection of components
Deficient materials
"Batch" problems
System/subsystem/CI reliability
System/subsystem/CI maintainability
System Safety

Once deficiencies are identified, formal corrective actions are required. At this time, production units are under configuration control, in accordance with requirements stated in MIL-STD-480 and MIL-STD-481. As such, any changes to production units must be approved by the cognizant authority, in accordance with configuration change control procedures. Changes in the diagnostic capability product baseline are classified as either Class I or Class II changes, according to MIL-STD-480. Class I changes affect contractually specified form, fit, function, cost, or delivery schedule of a diagnostic element CI; must be in an engineering change proposal; and must be approved by a Configuration Control Board (CCB) chairman before their implementation. Class II engineering changes are not approved per se but are reviewed by the cognizant plan representative for concurrence in classification. Page 1 of DD Form 1692, or the contractor's internal form, is used for submitting Class II changes for concurrence in classification or approval/disapproval.

4.2.4.3 Diagnostic performance assessment and evaluation. Verify by testing that an assessment of the diagnostic elements capability is performed during the system/subsystem/CI production test phase and verify that proper corrective actions are taken.

Verification Rationale

Including verification requirements in the acceptance test procedures is the most cost-effective and reliable method for verifying that the impact of a diagnostic deficiency on diagnostic elements has been considered.

Verification Guidance

When the verification procedures are incorporated in the acceptance test procedures, the verification is accomplished as part of the acceptance procedure. Implement configuration control change procedures delineated in AFR-14-1 and MIL-STDs-480, 481, 482, and 483.

APPENDIX A

Verification Lessons Learned

Effective verification can best be achieved when there is a minimum impact on funding requirements, when it is integrated into the mainstream of business, and when it will not create additional personnel qualifications.

Configuration control procedures have a long history of effectiveness and have incorporated many lessons learned. Adherence to the published configuration control procedures is the best way to verify configuration control.

3.2.5 Change approval process. Identified diagnostic element performance deficiencies shall be corrected and the impact of system design changes on the diagnostic capability shall be considered.

Requirement Rationale

Diagnostic element configuration control must be exercised by both the contractor and the Government to ensure that all desired changes to the diagnostic capability are incorporated in a technically sound and cost effective manner and that non-diagnostic changes do not degrade the required diagnostic capability.

Requirement Guidance

The Configuration Control Board (CCB) is the agency that acts on all proposed changes. The Program Office should establish internal procedures for assigning change priorities and procedures that include the diagnostic elements. The detailed checklist developed by each office to review the proposed ECP, using MIL-STD-480 and AFR 14-1, should contain the appropriate references to the diagnostic elements.

A Technical Data Review, using AFTO Form 22 (Technical Order System Improvement Report), AF Form 847 (Recommendation for Change) and T.O. 00-5-1 Guidelines, would correct errors or omissions in existing technical documents.

4.2.5 Change approval process. Verify through inspection that the change process for correcting diagnostic deficiencies is implemented.

Verification Guidance

Implement the ECP change process described in AFR 14-1 and MIL-STDs-480, 481, and 482. Perform the technical data change process using T.O. 00-5-1 guidelines. Inspect the results of each change using the procedures described in 3.2.3.

3.2.6 Program management responsibility transfer. All diagnostic elements shall be included in the Program management responsibility transfer (PMRT) and responsibility for continued engineering management and logistic support shall be assigned.

Requirement Rationale

Since maintenance diagnostic elements are included in the prime weapon system platform as an entity (e.g., SIT), embedded in the prime system/subsystem/equipment (e. g., BIT), or stand-alone support system CIs (e.g., ATE), guidance and procedures must be provided to ensure

that all of the diagnostic elements are included in the turnover agreements either separately or as part of a CI.

Requirement Guidance

Implement procedures in the form of a checklist and guidance material to identify the various elements of the diagnostic capability that must be considered for PMRT.

4.2.6 Program management responsibility transfer. Verify through checklist evaluation that the PMRT for the diagnostic elements has been accomplished.

Verification Rationale

The use of a checklist by both the implementing command and the supporting command will ensure that the responsibility for all the diagnostic elements has been assigned.

Verification Guidance

The diagnostic element checklist should be formulated for each PMRT and, as a minimum, should include the following.

Has the product baseline been established for the diagnostic element (e.g., BIT, SIT and ATE)?

Has the PCA been satisfactorily completed for each diagnostic element?

Have identification and documentation of remaining tasks been completed?

Has availability of diagnostic element data needed to support the diagnostic element been ascertained?

Have diagnostics-related PMRT plans been approved by the AFSC SPO and the proper AFLC organization?

Has a PMRTWG agenda been published?

Have the PMRTWG activities been completed?

Has the diagnostic element transfer milestone chart been kept current and action initiated, when necessary, to correct deficiencies and schedule slippages?

Verification Lessons Learned

Failure to verify that appropriate actions have been taken to transfer responsibility to supporting commands may lead to logistic support gaps once the weapon system is deployed.

3.3 DEPLOYMENT

3.3.1 Deployed diagnostic element performance assessment. A method for identifying and tracking diagnostic element performance during deployment shall be established by implementing data collection and maturation plans developed during the Development and Production Phases in concert with Milestone IV, Logistic Readiness and Support Reviews.

APPENDIX A

Requirement Rationale

The development and maturation of diagnostic capability is not complete when the weapon system is initially placed in field use. It is necessary to continue reporting, investigating, tracking, and resolving sources of diagnostic errors to continue the maturation process.

Requirement Guidance

Plans for data collection and diagnostic maturation should include the interface with, and use of, existing Air Force Maintenance Data Collection and Material Deficiency reporting systems, to enable timely assessment of deployed diagnostic element performance.

Data collection requirements defined in the Development and Production Phases should be implemented. Data collection should include a description of diagnostics-relevant operational anomalies and maintenance actions. Data collection should be integrated with similar data collection procedures, such as those for reliability, maintainability, and logistic support analysis. Analyze the data to determine if BIT/SIT hardware and software, ATE, TPS, maintenance information, training results, skill levels and manpower, and diagnostic reliability and maintainability are meeting specifications in terms of fault detection, fault isolation/resolution, false indications, fault detection times, fault isolation times, etc., for all levels of maintenance.

The diagnostic element performance assessment should identify both satisfactory and deficient diagnostic elements. Capture the analysis results in the diagnostic database established as part of the development process for use by future development programs. Initiate corrective action in accordance with guidance contained in 3.3.2.1.

4.3.1 Deployed diagnostic element performance assessment. Verify diagnostic element performance in the field by assessing the implementation of the maturation plan.

Verification Rationale

The verification of the deployed diagnostic capability should be included in the Diagnostics Maturation Plan, as this plan is part of the development process, and should be updated periodically as new data is made available.

Verification Guidance

The Diagnostic Maturation Plan provides procedures for verifying that the data collected is analyzed and incorporated in the diagnostic database established for the particular program. Additionally, the plan should include procedures to verify that Material Deficiency Reports are processed in accordance with the current Air Force procedures. Thus, the information contained in the plan can be used as a checklist to determine if the methods used for identifying and tracking diagnostic performance are adequate.

Verification Lessons Learned

The absence of procedures to verify the collection of diagnostic data and its analysis to assess the diagnostic performance will result in the omission of pertinent activities, since diagnostic performance assessment has little or no management visibility.

3.3.1.1 Deployed diagnostic element corrective action. Procedures and guidance for implementing diagnostic deficiency corrective action shall be provided.

APPENDIX A

Requirement Rationale

Diagnostic elements are integral to the weapon system and to the associated support system and span all levels of maintenance Therefore, cohesive procedures are required to implement an effective diagnostic corrective action.

Requirement Guidance

Conduct engineering investigations for diagnostic deficiencies identified through analysis of data referenced in 3.3.2 and for deficiencies identified in Material Deficiency Reports generated by user organizations. These investigations should be conducted by the organizations assigned program management responsibility for particular diagnostic elements. Contractor support for investigations may be arranged, if necessary. Investigations should accomplish the following.

Verify the existence of a problem

Investigate alternative solutions

Recommend a specific practical solution

As a result of the investigation, a Modification Proposal and Analysis (MPA) is prepared and processed in accordance with AFR 57-4. The MPA may lead to the generation of an Engineering Change Proposal (ECP). As soon as a change is deemed necessary, notify all user commands of the existence of the problem and give a brief description of the expected correction, a work-around procedure for the problem, and the approximate date the corrected item is expected to be available in the field.

Review in detail the ECP and Deficiency Report that initiated the diagnostic element corrective action. Cover the particular diagnostic element deficiency, other embedded and external diagnostic elements, and all the associated logistic support elements. Mark up the diagnostic element-relevant product specification with changes generated by the diagnostic corrective action. The resulting document will be a diagnostic element modification product specification/segment.

Requirements defined in the above diagnostic element modification product specification/segment will be reviewed by Air Force personnel prior to contracting. The Air Force will decide on the proposed modifications, on the basis of diagnostic element warranty or maintenance contract, available Air Force assets, use of these assets, criticality of diagnostic modification schedule, cost to make the change, and cost to contract out. Cost to contract will be estimated from the procurement cost of the diagnostic element. This procedure will ensure that all major items are considered in defining the requirements. This task will also provide for an Air Force decision on whether the diagnostic element corrective action should be accomplished organically. The impact of the diagnostic corrective action on support of the diagnostic capability during deployment will be provided as part of the plan for accomplishing the corrective action.

As a result of the make or buy decision, generate a plan of action for accomplishing the corrective action. Include schedules and cost estimates; use of outside contractor's help, where required; detailed listing of all support assets that will be impacted by the corrective action; and a detailed listing of all organizations that must be notified of the diagnostic element final configuration.

4.3.1.1 Deployed diagnostic element corrective action. Verify through checklist evaluation implementation of the diagnostic deficiency corrective action.

Verification Rationale

Corrected diagnostic deficiencies are best verified by monitoring the Air Force-established ECP process with a checklist.

Verification Guidance

The verification checklist should provide answers to the following questions.

Have cost estimates been generated and analyzed for implementing the corrective action?

Have provisions been made to update all affected diagnostic element data?

If the change is the result of unsatisfactory diagnostic parametric values, such as fault detection/fault isolation levels, have updated values been specified prior to estimating the cost?

Have diagnostic element product specification/segment updates been completed prior to the start of the corrective action?

APPENDIX A

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APPENDIX B

20 REQUIREMENTS DERIVATION AND ALLOCATION PROCESS

20.1 SCOPE. This appendix outlines a requirements derivation and allocation (RDA) process that can serve as the backbone for developing the proper diagnostics for a weapon system. This process is described as it might apply when addressing any design level for any acquisition program. To determine how allocation would apply to specific acquisition phases, refer to Roadmap activities in Appendix I and related guidance in Appendix A. Refer to Appendix B.1 for an example of the process.

20.1.1 PURPOSE. The purpose of the RDA process is to describe how diagnostic requirements and associated verifications may be generated that accurately depict operational needs. This RDA process is iterative and results in clearly worded diagnostic requirements that do not unnecessarily constrain design options. There are many ways to derive and allocate requirements. This appendix addresses one method for diagnostics.

20.1.2 APPLICATION. This RDA process includes activities accomplished by both the Government and contractors. In general, the Government begins the process by specifying operational needs in contractual documents and then ensures that contractor efforts to derive diagnostic requirements and to allocate these requirements accomplishes the needs. In practice there may not be clear cut distinctions between Government and contractor responsibilities for a given step, or this distinction may be different for individual programs. This appendix describes the process as it should be performed by whoever has been tasked to perform each step for a given program.

This RDA process is designed to work within a system engineering environment. System engineering interactively considers all aspects of designing a product in all design phases. This method makes possible tradeoffs with timely inputs from all design disciplines and results in initial designs that meet overall system requirements.

To perform the various activities of this RDA process information is needed, manipulated, and produced. Specifics on RDA information flow is provided in Appendix F.

References are made to design levels throughout this appendix. Figure 5 lists these levels and provides examples of what each level covers. System is considered the highest design level and assembly the lowest.

DESIGN LEVELS	System	Segment	Element	Subsystem	Assembly
Typical items under levels	(Top level, no breakout)	Vehicle, Support system, Training...	Electronic, Avionic, Structures, Mechanical, Propulsion...	RADAR, Sensors, Flight control, Communications, Navigation, Electrical power, Crew station...	LRU, LRM, SRU, Card...

Figure 5 Design Levels

APPENDIX B

20.2 APPLICABLE DOCUMENTS.

(NOTE: These documents are not to be applied contractually except to the extent that specific portions are cited in the requirement statements or verification statements.)

20.2.1 Government documents

20.2.1 Specifications, standards, and handbooks

MIL-STD-470	Maintainability Program for Systems and Equipment
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-882	System Safety Program Requirements
MIL-STD-1388-1	Logistic Support Analysis
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment, and Facilities
AFGS-87256	Integrated Diagnostics

20.3 PROCESS. The RDA process includes three major activities: translation, collation and allocation. Translation and collation together derive a set of diagnostic requirements that can lead to satisfying the established needs. Allocation shapes and moves those requirements to the appropriate resources and design levels for implementation. These activities are repeated at each design level, by building upon earlier efforts, to ensure integration. The quality and quantity of information available to perform the process may vary. It is important to perform the process early, even if rough or speculative information is used. Waiting for precise data to accomplish the process the first time runs the risk of missing the initial design and involving expensive retrofits. Figure 6 illustrates these activities.

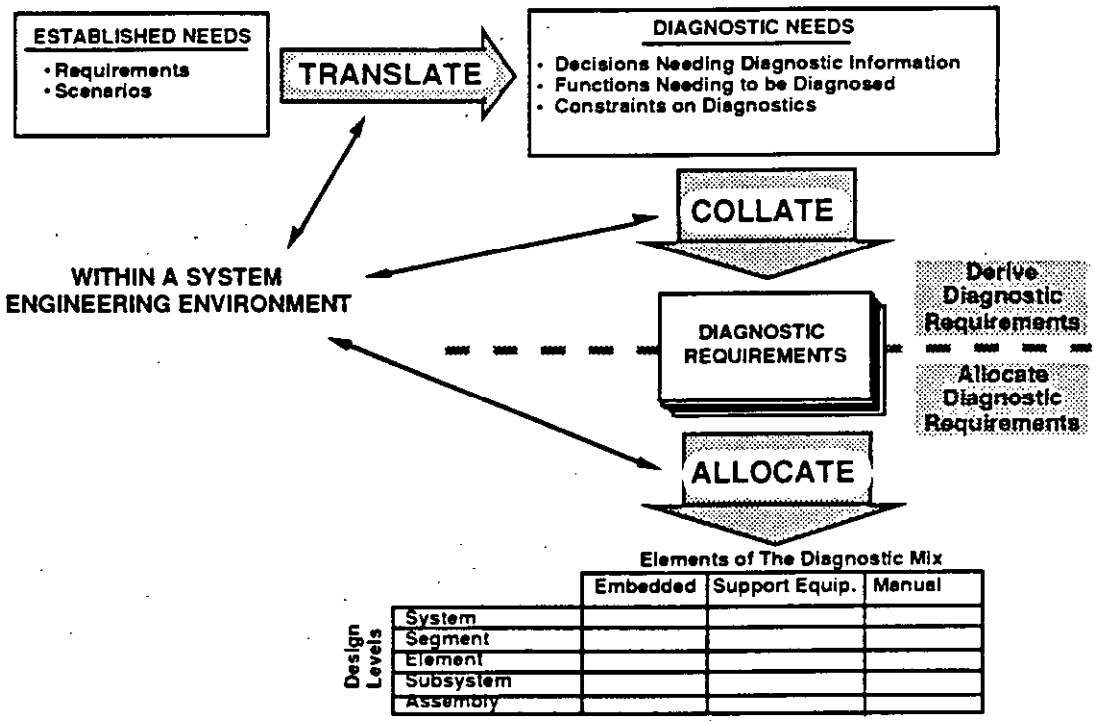

Figure 6 Requirements Derivation and Allocation Activities

The RDA process provides traceability of diagnostic design requirements to the operational needs they are supporting. This traceability, when adequately documented, validates the need for diagnostic requirements and helps perform in-process verification of the design.

RDA is iterative as a program moves through acquisition phases. Revisions occur under the following conditions.

As more time or better information becomes available
As tradeoffs indicate a need to reapportion resources or constraints
As driving requirements change

20.3.1 TRANSLATE ESTABLISHED NEEDS. Translation breaks a program's established needs into terms meaningful for creating diagnostic requirements. Established needs are considered to be the statements of what the product must be that are driving the program activity. The source of these statements will vary depending upon where a program is in its acquisition process, typically beginning with a SON and going through SORDs, DSRDs and RFPs. Translation is critical as it establishes a link between operational needs and the diagnostic requirements that are to be derived. This link can be used in system engineering tradeoffs to evaluate the criticality of diagnostic capabilities. This link, when adequately documented, also validates that operational needs are being addressed by the system's requirements and provides a framework for in-process verification. Translation details are covered below and summarized in Figure 8.

20.3.1.1 Established needs. A system's established needs should accurately reflect what must be provided without unnecessarily restricting how it can be done. Operational needs, such as system safety, sortie generation rate, and mission completion success probability, and support needs, such as maintenance man hours per flying hour and two-level

maintenance concepts, all drive the need for diagnostics. The prime source of established needs are the following documents..

Statement of Operational Need, Requirements Correlation Matrix and Preliminary System Operational Concept. The SON, its attached RCM, and the PSOC, if one is available, are the initial documents for specifying operational requirements. Appendix A, 3.1.1.1, discusses preparing a SON and RCM and Appendix E, 60.2, contains a matrix to assist in creating RCMs.

System Operational Requirements Document and RCM. As a program progresses through acquisition phases the SORD and its attached RCM document the evolution of operational requirements. Appendix A, 3.1.1.1, 3.1.2.8, 3.1.3.7, and 3.1.4.9 cover preparing SORDs and RCM updates.

Depot Support Requirements Document (DSRD). The DSRD describes the supporting command's plans and requirements for providing both depot maintenance and material support. Appendix A, 3.1.2.9, 3.1.3.8, and 3.1.4.9.1 cover diagnostic inputs to DSRDs.

Other key program documents are based upon the above sources and should also accurately reflect operational and support needs. One such document is the Request For Proposal (RFP). RFPs relay Government requirements for a system to contractors and form the basis for the initial design work that should include initial diagnostic efforts. Appendix A, 3.1.2.2, 3.1.3.2, 3.1.4.2 and 3.2.1 discuss incorporating diagnostics into RFPs.

20.3.1.2 Determine diagnostic needs. Assess established needs to determine three types of diagnostic needs: decisions/events, constraints, and functions.

20.3.1.2.1 Determine decisions/events. Diagnostics provides information about the state (health) of a system that supports various decisions, such as deciding what part to replace or whether a missile may be safely launched. Identifying the decisions that need diagnostic information provides both the rationale for having diagnostics and the initial timing and quality criteria (an inflight decision on whether a function needs to be reconfigured may require fault detection, isolation, and reporting with tight time and accuracy constraints). Consider all mission, safety, and maintenance decisions to cover all needs for diagnostic information.

Analyze mission scenarios to determine when diagnostic information will be needed to support identified decisions. Points when diagnostic information is needed are referred to in this standard as diagnostic events. A particular system might require some of the following diagnostic events, several of which are illustrated in Figure 7.

Mission
- Premission/use (e.g., preflight checkout)
- During mission initiated (e.g., pilot initiated self test)
- During mission continuous (e.g., inflight flight control monitoring)
- During mission restoration (e.g., inflight reconfiguration or redundancy)

Safety
- Premission/use (e.g., preflight checkout of safety-critical items)
- During mission initiated, continuous, or restoration (similar to mission, but oriented toward safety functions)

Maintenance
- Premission/use (e.g., maintenance preflight checkout)
- Postmission/use (e.g., postflight inspection)
- Scheduled inspections (e.g., 200 hr inspection)
- Restoring system functionality (e.g., organizational troubleshooting)
- Restoring asset functionality (e.g., intermediate or depot troubleshooting)

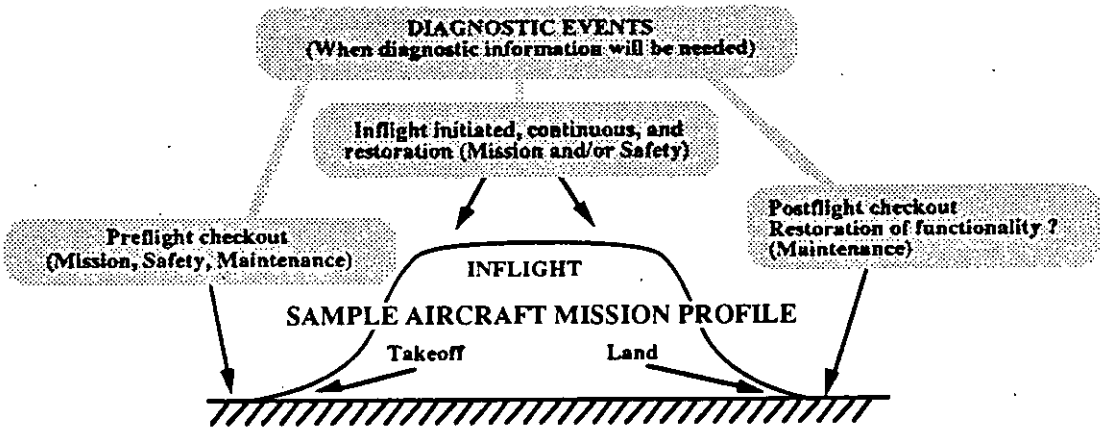

Figure 7. Diagnostic Events

It may be possible to group decisions under diagnostic events to simplify diagnostic requirements (there are several maintenance decisions applicable to diagnostics during postflight, etc.).

Non-diagnostic design decisions can also create diagnostic decisions and events. An event, such as loss or degradation of a reconfigurable resource during use, may not have been established in the original system operational requirements but may have been created by a decision to use reconfiguration to solve safety and reliability conflicts.

Diagnostic events may also serve information needs that are not directly related to operational needs. Design verification, engineering change proposal kit proofing, training, acceptance testing, etc., are some areas that also need diagnostic information. Providing events to address the need for such information early in a program may result in savings by eliminating redundant test algorithms, test setup, and test execution.

20.3.1.2.2 Determine constraints on diagnostics. There are established needs that constrain options available for obtaining or reporting diagnostic information. Such established needs may not indicate that diagnostics is needed. However, they do specify that if diagnostic capability is required, it must be provided within certain limitations. Constraints may play a driving role in determining the diagnostic mix for a system. An example would be mobility

requirements that constrain the use of support equipment at deployed locations. Constraints may also drive diagnostic accuracy. A critical diagnostic event with constraints limiting weight and space may drive the need for highly accurate information from a single diagnostic source. A similar event with few constraints might be satisfied with a set of less accurate diagnostic sources that combine to provide the required accuracy.

20.3.1.2.3 Determine functions needing to be diagnosed. It is necessary to determine what system functions (destroy tanks, carry cargo, detect targets, communicate, etc.) should be diagnosed to provide the diagnostic information needed to make any identified decisions. Using functions allows diagnostics to be specified early in a design. Design teams deciding how a system should perform the navigation function (i.e., provide navigational information to the operator) can also decide how to provide needed diagnostic information on the navigation function to the operator and maintainer. Design teams can then address diagnostics interactively with performance.

The functional orientation also allows requirements to be allocated in a top down fashion. As efforts progress, the design becomes more detailed and functions break into subfunctions at continuously lower design levels until functional requirements are implemented as physical design requirements.

20.3.1.2.5 Methods for determining diagnostic needs. Diagnostic needs may either be directly stated in a weapon system's established needs or they may be derived from operational and support measures that diagnostics contributes to meeting.

Operational needs might include requirements for preflight verification of mission critical functions, inflight notification of loss of safety critical functions, or similar requirements. In these cases diagnostic needs are directly stated and translation is straight forward.

It is most likely, however, that diagnostic needs will have to be derived from a program's operational and support needs. A need for a sustained sortie rate should lead to a need for diagnostic information to help decide how to quickly restore a function or to decide whether an aircraft should be turned, repaired, or set aside for later maintenance. Analyze the constituents of such operational and support measures to break out the contribution that diagnostics must make. Sources of useful information are LSA Tasks 101 and 201, engineering information bases of comparative analyses and new technologies, and outputs from any prior acquisition phases of the program.

20.3.1.2.6 Inputs from design decisions. As a program progresses solutions to non-diagnostic requirements are decided upon. These solutions may call for additional diagnostic information. An example is a decision to extend dormant reliability by periodic function testing. Such design decision-derived needs for diagnostic information should be added to the diagnostic needs that were derived from the established needs.

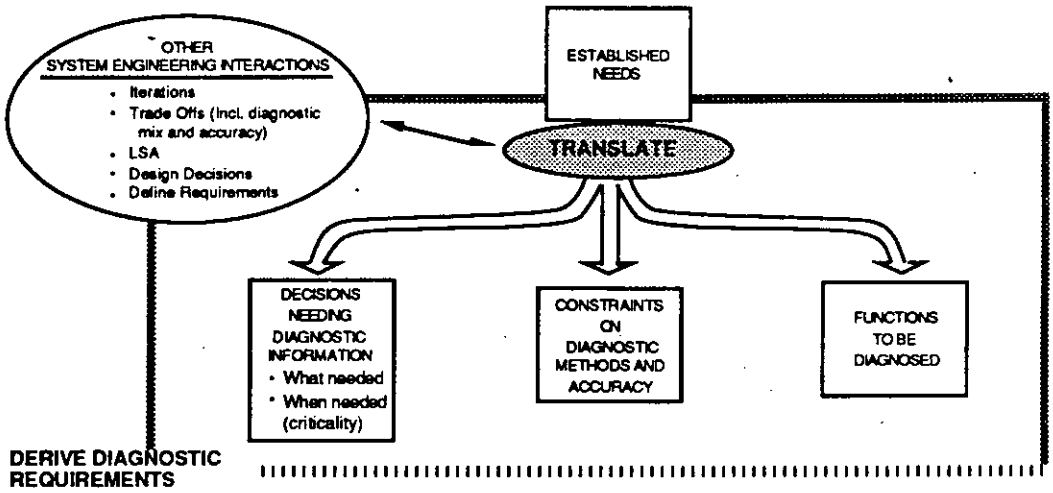

Figure 8 Translation Activity

20.3.2 COLLATE NEEDS INTO DIAGNOSTIC REQUIREMENTS. Associate the functions for which diagnostic information is needed with the events when the information is needed and with applicable constraints, accuracy, and metrics. Bring them together into a complete set of diagnostic requirements, with associated verifications, for the appropriate design levels. Collation is described below and illustrated in Figure 9.

20.3.2.1 Collation inputs. There are several sources of inputs to the collation activity. Translation is the primary source for initial phases. In later phases, design decisions and diagnostic requirements derived in earlier phases and allocated to the level at which the current collation is taking place become primary.

20.3.2.2. Determine needed diagnostic requirements. Determine for each of the diagnostic events the system functions that must be reported (or conversely, for each system function, determine at which events diagnostic information is needed). Functions may be grouped by category, such as mission critical. For each of these events (or groups of functions), select a generic diagnostic requirement and its associated verification from the AFGS-87256. Translation may identify the need for diagnostic information pertaining to functions or decisions at several design levels. An early "system-level" SORD and RCM may contain weapon system needs, specifics on air vehicle performance requirements (segment level), and specifics on using Government furnished equipment, such as engines or radios (subsystem and assembly levels). Select generic requirements from the appropriate design level in AFGS-87256 to cover the level of the functions or decisions being addressed.

If collation inputs include previously derived diagnostic requirements that have been allocated to the design level at which the collation is taking place, they should be combined with the above inputs to ensure complete coverage and minimize duplication.

20.3.2.3 Tailoring diagnostic requirements to meet system needs. Tailoring requirements means wording them to say what is required for a specific system and phase without saying how to do it, unless a system constraint or design decision has been made that mandates saying how. Tailoring guidance for each requirement and verification selected from AFGS-87256 is provided in Appendix A of AFGS-87256. These requirements should satisfy a wide range of needs. If necessary, create new requirements using AFGS-87256 for examples and provide update/revision feedback per instructions in AFGS-87256.

APPENDIX B

To tailor diagnostic requirements, determine which specific functions need to be diagnosed to accomplish each decision/event. These functions should have been identified during translation (see 20.2.1.2.3).

For each blank in the requirement statement, insert the word, phrase, or reference that clearly describes that need for the weapon system. If the structure of the sentence interferes with clearly stating what is needed, rephrase it . The same functions may need to be diagnosed in support of different events, such as fault detection and isolation of safety critical functions in support of both inflight reconfiguration and turnaround maintenance. Similarly, a given decision/event may need diagnostic information on several functions. Diagnostic requirements can be formed in any of the following ways.

a. Each function and decision/event combination may form a separate requirement.
b. Each function may form a separate requirement that includes a list of all decisions/events for that function (may refer to an external list).
c. Each decision/event may form a separate requirement that includes a list of all functions needing diagnostics for that decision/event (may refer to an external list).
d. A table with events and functions on separate axes may be used, with applicable intersections checked.

Including decisions/events in diagnostic requirements maintains the link between diagnostics and operational needs. It also relays any timing and criticality implications without having to establish specific time or accuracy constraints any sooner than necessary. There is a point in the design process, however, at which mentioning decisions/events should give way to specifying specific timing and accuracy criteria. This point will depend on the acquisition phase, the design level being addressed, and the design decisions made.

Timing. Diagnostics to support inflight reconfiguration will need rapid fault detection, whereas depot maintenance may be satisfied with more time consuming diagnostics.

Accuracy. Accuracy of diagnostics affects user confidence in diagnostics, needs for alternate diagnostic resources (TO coverage to compensate for inaccurate BIT fault isolation), and needs for compensating non-diagnostic resources (more spares needed due to high CND rates). Inflight events tend to need higher accuracy than a depot repair event as the consequences of making a wrong decision are greater inflight.

When accuracy is specified in a diagnostic requirement, it should be in terms related to the language of the diagnostic requirement. Top level requirements should relate accuracy to top level measures that diagnostic accuracy will influence. Top level measures may also depend on other factors, such as reliability and maintainability, but should be used until system engineering efforts isolate the specific diagnostic factors for lower level requirements. These measures can be broken into the need for confidence in fault indications being accurate (limits on false alarms) and confidence in the accuracy of indications that no faults exist (limits on missed faults). Confidence in the accuracy of diagnostic indications should eventually give way to firm requirements for fault coverage and for reliability of the diagnostic method chosen in both reporting faults it was designed to cover and in not reporting faults that do not exist. See Appendix D for more details on accuracy metrics.

Relate constraints on diagnostics to diagnostic requirements. Constraints should have been identified during translation (see 20.2.1.2.4). They may be incorporated into the wording of the requirements or added as a constraint listing referenced in requirements. Constraints to top

level diagnostic requirements may be incorporated into the wording of lower level requirements, or eventually disappear, as design decisions are made and the allocation covered in 20.2.3.3 occurs.

Create verifications for each requirement. Determine the proper verification method for the particular program and phase, as discussed in Appendix H and in the guidance for each verification in AFGS-87256, Appendix A. Consider that there are three relevant aspects of verification. The first is validation of requirements to ensure that requirements fully describe the diagnostics needed to do the job, no more and no less. The second aspect is in-process verification, assessing the probability that the design effort will achieve contractual requirements within acceptable risk. The third aspect is qualification, determining if the final product meets its requirements. See 20.3 for the relationship of this RDA process to these aspects of verification.

20.3.2.4 Collation outputs. The result of collation activities should be a consolidated list of diagnostic requirements and associated verifications. This list should define what diagnostics must provide to meet the established needs. The list should cover all needs, address all elements of the diagnostic mix, preclude conflicts, and avoid unnecessary duplication. The list may end up as specifications between Government and contractors, between prime contractors and sub contractors, or as internal design guidance. The following sections in Appendix A discuss specifications: 3.1.2.7, 3.1.3.6, 3.1.4.4.1 and 3.1.4.7.3.

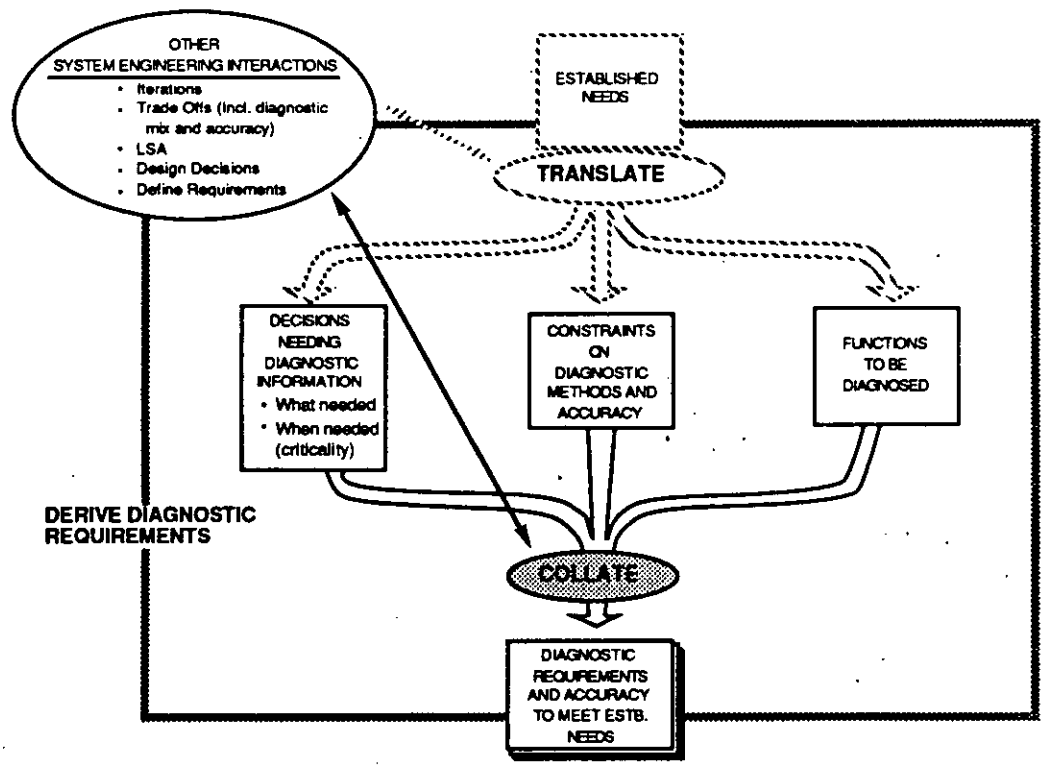

Figure 9 Collation Activity

20.3.3 ALLOCATION. The objective of allocation is to properly implement the diagnostic requirements derived by the translation and collation activities. There are two aspects to allocation. One is determining how each element of the diagnostic mix should contribute to satisfying diagnostic requirements. The other is to determine at what design level

functional diagnostic requirement should be implemented as physical design requirements. These determinations should be based on analyses, tradeoffs, considerations of capabilities of lower design levels, the diagnostic mix at higher levels, and non-diagnostic system engineering assumptions or design decisions that were influenced by diagnostic capability or accuracy. The task is similar to filling in the matrix in Figure 10 with diagnostic requirements applicable to a specific program.

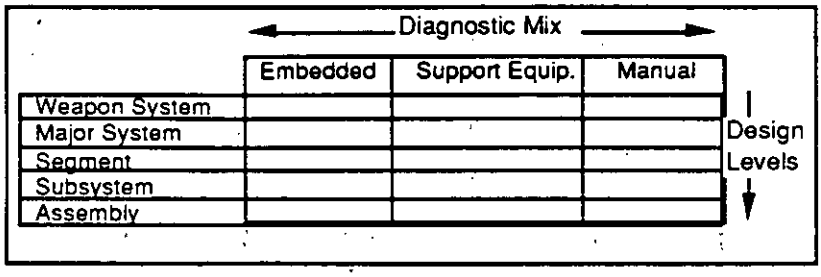

Figure 10 Two Aspects of Allocation

Implementation is the core of the allocation activity. Implementation is the transition of functional diagnostic requirements to physical items that meet these requirements. This transition should take place in the following stages.

Determining the diagnostic mix
Passing down requirements to enable mix decisions
Establishing requirements for physical items
Building the items

Only the first three stages are addressed in this appendix. Production Phase activities on the Roadmap cover building diagnostic capability. Allocation is expanded in the following sections and illustrated in Figure 11.

20.3.3.1 Determining the diagnostic mix. The first stage is assigning resources to obtain the required diagnostic information. Diagnostic information may be obtained using resources from several categories, such as BIT, SE, instructions in technical manuals, etc. An example is a requirement for diagnostic information on safety and mission critical aircraft functions to support a preflight decision on whether an aircraft should be accepted for a mission. The first stage in implementing this requirement is deciding to use embedded resources on the aircraft, TO checklist pages, and trained personnel to obtain the diagnostic information . The combination of resources from each category used to satisfy diagnostic requirements is called the diagnostic mix.

This stage sets the initial diagnostic mix and should occur at the design level appropriate to the event/decision needing the information. In the above example, the preflight event is pertinent to the entire vehicle and should be addressed, therefore, when considering the segment design level. The resources available for implementing a requirement can be dictated by the mix established at a higher design level. See Appendix H for a breakdown of diagnostic mix elements.

20.3.3.2 Passing down requirements to enable mix decisions. The next stage in implementation is to pass down any need for supporting diagnostic information or interfaces. In the 20.2.3.1 example, the safety and mission critical functions could result in requirements for diagnostic information from flight control, life support, target detection, navigation, and

communication subfunctions, which could continue to pass down requirements to their relevant subfunctions. Additionally, any needs for interfaces between the various mix elements might need to be passed down.

20.3.3.3 Establishing requirements for physical items. The last stage addressed is establishing detailed specifications to produce the items that will make up the diagnostic capability. Some examples are (1) algorithms and circuitry for BIT, (2) interfaces and Test Program Sets for support equipment, (3) and instructions for inclusion in the T.O.s. Once established to meet a diagnostic functional requirement, these physical requirements can be implemented like those for any other algorithms, circuitry, and instructions not necessarily related to diagnostics. This appendix focuses on the first two stages. Once detailed specifications are established, they may then be further broken down, if necessary, using conventional techniques into lower level physical requirements until the complete hardware/software solution is defined.

20.3.3.4 Passing down requirements without implementation actions. There are situations in which no implementation stages should be taken. Instead, the applicable diagnostic requirement should be passed down to lower design levels for action. If a diagnostic requirement concerns events applicable to a design level below the level currently being addressed it should be passed down to that level for implementation. (A requirement to provide diagnostic information to validate intermediate or depot level repairs on SRUs may be known while addressing the segment design level but should be passed down to the subsystem level for implementation.)

A functional requirement should be passed down if implementation at a lower design level is beneficial. Consider characteristics such as cost, efficiency, performance, or feasibility of design. A source of information for the analysis is an information base, such as designers who deal with those levels.

20.3.3.5 Ways to pass down requirements. There are several ways requirements can be passed to lower design levels.

They can be passed straight through to one item or many items in the next level with only minor wording changes. An example is for "all mission critical failures of the avionics element to be reported..." to be allocated to "all mission critical failures of the fire control function to be reported..." and also to the navigation function, etc.

They can be expressed in terms of different resources needed to implement them. An example is the requirement to indicate the status of an engine to the aircrew during use. This might require functional requirements for the propulsion system specification to provide the information and physical requirements for the controls and displays subsystem specification to display the information.

More than one requirement can be combined into a single requirement. An example is requirements for status of certain subsystems for supporting an inflight go/no-go decision and for supporting inflight reconfiguration decisions that might be combined into one requirement for a particular subsystem.

See Appendix B.1, Process Example, for samples of the various ways to assign requirements to lower design levels.

Requirements for new design levels may be selected and tailored, along with their associated verifications, from the generic requirements in AFGS-87256. As the level of design changes,

changes, so does the language of the requirements. Prime system requirements expressed in terms of range, payload, and delivery accuracy may translate to requirements in terms of pounds-thrust, wing loading, and pointing accuracy. Diagnostic requirements also should be expressed in terms applicable to the level of design and the capability being specified. In early acquisition phases, functions should be addressed rather than specific hardware, and decisions/events should be addressed rather than specific time or quality criteria. Hardware and specific timing and quality criteria should be addressed only after design decisions have been made that mandate such detail or if program constraints force this detail. See 20.2.2.3 for tailoring guidance.

20.3.3.6 Requirements unable to implement. If a requirement can not be accomplished at the current level of design or below, determine if it may be accomplished by reiterating collation or changing the implementation approach for the current level. If not, determine if it may be accomplished at a higher level or whether the diagnostic concept or requirements, up to and including operational requirements, should be reassessed. The system design might need to be modified and the system engineering process might need to be reiterated. If this step changes higher level requirements, reiterate the RDA process starting at the level where the change was made.

20.4 RELATIONSHIP OF PROCESS TO VERIFICATION. The RDA process results in lists of diagnostic requirements and verifications, along with the knowledge of which operational needs or design decisions they came from and the reasoning behind their selection. When adequately documented, this information provides a framework for accomplishing the validation of requirements, in-process, and qualification aspects of verification. See Appendix H for an additional discussion of verification.

To validate requirements, synthesize and analyze subordinate functional requirements and physical implementations to determine if they properly describe a design that can meet the established needs. Documentation from the RDA process can accomplish this validation, since the logic used to create subordinate requirements can be used to evaluate their validity. If a requirement can not be validated, the RDA process was faulty or the established needs can not be met within given constraints.

To perform in-process verification, analyze the design at its current stage to determine if it can meet contractual requirements. Address validity of the requirements and the risk of their being accomplished. This is a more complex aspect of verification. It should still be based on documentation of the RDA process, with the addition of risk data, until the design is close enough to completion that physical items are available for evaluation.

The qualification aspect of verification determines if the item being verified meets its requirements and is accomplished by techniques, such as simulation, test, demonstration, evaluation,or operation of the item. Qualification is not usually performed using the requirements derivation and allocation process but is in effect a measure of the effectiveness of the process.

The following sections in Appendix A cover in-process verification activities by phase: 3.1.2.6, 3.1.3.9, 3.1.3.11, 3.1.4.4, 3.1.4.6, 3.1.4.10, and 3.1.4.10.1.

APPENDIX B

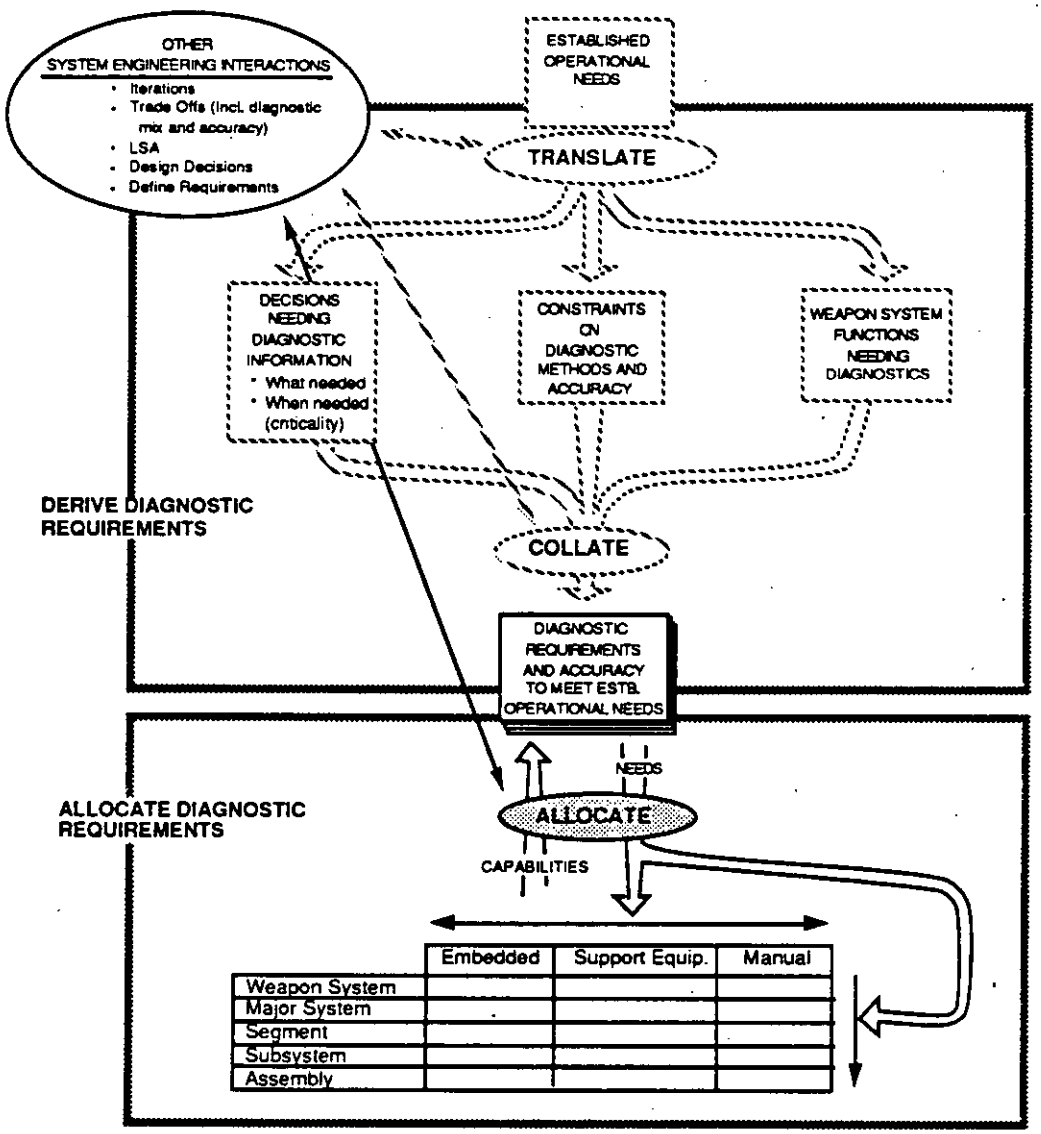

Figure 11 Allocation Completing the Requirements Derivation and Allocation Process

20.5 PROCESS RESULTS. The result of the requirements derivation and allocation process is a logically derived set of diagnostic requirements and verifications, for all available diagnostic resources and at each applicable design level, that fully describes the needed diagnostic capability of a system. The requirements end up as hardware or software specifications, the verifications state how compliance with the specifications is to be evaluated, and the process itself is a structure for performing in-process verifications.

The translation, collation, and allocation activities should be accomplished for each design level and and reiterated as stated in 20.2. Each iteration should build upon previous efforts. The activities may vary with each iteration. Early efforts should focus on translation and collation with tentative allocations. Subsequent efforts should build upon earlier efforts and focus on translation of changes or additions to established needs, collation at new design levels being addressed, and more concrete allocations. Final efforts should concentrate on collation at lowest design levels and finalizing allocations. The following sections in Appendix A discuss

how the requirements derivation and allocation process may be accomplished in specific phases or between specific design levels: 3.1.2.4, 3.1.3.4, and 3.1.4.4.

20.6 INTERFACE WITH LOGISTIC SUPPORT AND ENGINEERING DISCIPLINES. The RDA process is accomplished in conjunction with the LSA process and other engineering disciplines (i.e., reliability, maintainability, human engineering, and safety). Integration of the diagnostic capability is dependent on good and timely communication with the various tasks under these areas. This section identifies the relationships between inputs and outputs of the RDA process and such tasks.

Tables 2a, 2b, 3, and 4 depict relationships between other disciplines and the RDA process as addressed in Roadmap Activities 3.1.2.4, 3.1.3.4, and 3.1.4.4. For each major RDA activity listed on the vertical axis, inputs from tasks in the other disciplines are shown, along with any outputs from the activities that feed into the tasks. Documents referred to in the tables are listed below.

MIL-STD-1388-1	Logistic Support Analysis
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-470	Maintainability Program for Systems and Equipment
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment, and Facilities
MIL-STD-882	System Safety Program Requirements

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Table 2a LSA Interface with Allocation Process

MILITARY STANDARD 1388-1 TASK NUMBERS, part A								
	INPUT TO AND OUTPUT FROM ALLOCATION TASKS							
	101 OUTPUT	201 INPUT	202 INPUT	203 INPUT	204 INPUT	205		
						INPUT	OUTPUT	
ALLOCATION AT WEAPON SYSTEM LEVEL	LSA strategy	Supportability factors relating to intended use	Constraints based on existing logistic resources	Baseline comparison system data	Prime sys technology to be applied	Quantitative supportability values and design goals		
ALLOCATION AT MAJOR SYSTEM LEVEL	LSA strategy	Supportability factors relating to intended use	Constraints based on existing logistic resources	Baseline comparison system data	Prime sys technology to be applied	Quantitative supportability values and design goals	System-level diagnostic concept and characteristics	
ALLOCATION AT SEGMENT LEVEL				Baseline comparison system data	Prime sys technology to be applied	Quantitative supportability values and design goals	System-level diagnostic concept and characteristics	
DEVELOP SUBSYSTEM DIAGNOSTIC REQMTS				Baseline comparison system data	Prime sys technology to be applied	Quantitative supportability values and design goals	System-level diagnostic concept and characteristics	
DEVELOP ASSEMBLY DIAGNOSTIC REQMTS								

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Table 2b LSA Interface with Allocation Process

MILITARY-STANDARD 1388-1 TASK NUMBERS, part B							
	INPUT TO AND OUTPUT FROM ALLOCATION TASKS						
	301 INPUT	302 INPUT	303		401 INPUT	402 INPUT
			INPUT	OUTPUT		
ALLOCATION AT WEAPON SYSTEM LEVEL						
ALLOCATION AT MAJOR SYSTEM LEVEL	Operation and support functions	System support concept	Establish supportability requirements	Evaluation of diagnostic concept alternatives		
ALLOCATION AT SEGMENT LEVEL	Operation and support functions	System support concept	Establish supportability requirements	Evaluation of diagnostic concept alternatives		
DEVELOP SUBSYSTEM DIAGNOSTIC REQMTS	Operation and support functions	System support concept	Establish supportability requirements	Evaluation of diagnostic concept alternatives		
DEVELOP ASSEMBLY DIAGNOSTIC REQMTS	Support functions	Lower level support plan	Establish supportability requirements	Evaluation of diagnostic concept alternatives	Analysis of maintenance tasks	Assessment of potential field problems

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Table 3 Maintainability and Safety Interfaces with Allocation Process

	MIL-STD-470						MIL-STD-88	
	INPUT TO AND OUTPUT FROM ALLOCATION TASKS						2	
	201		202		203	204	201	202
	INPUT	OUTPUT	INPUT	OUTPUT	INPUT	INPUT	INPUT	INPUT
ALLOCATION AT WEAPON SYSTEM LEVEL							Safety monitoring reqmts	
ALLOCATION AT MAJOR SYSTEM LEVEL							Safety monitoring reqmts	Hazard analysis
ALLOCATION AT SEGMENT LEVEL	$\bar{M}$ model structure	Inputs to $\bar{M}$ model for allocation method	$\bar{M}$ allocation information	Allocated CI diagnostic reqmts	$\bar{M}$ predictions	FMEA data		Hazard analysis
DEVELOP SUBSYSTEM DIAGNOSTIC REQMTS	$\bar{M}$ model structure	Update $\bar{M}$ model (feedback)	$\bar{M}$ allocation information	Allocated CI diagnostic reqmts	$\bar{M}$ predictions	FMEA data		Hazard analysis
DEVELOP ASSEMBLY DIAGNOSTIC REQMTS			$\bar{M}$ allocation information	Allocated CI diagnostic reqmts	$\bar{M}$ predictions	FMEA data		

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Table 4 Reliability and Human Engineering Interfaces with Allocation Process

	MIL-STD-785				MIL-H-46855			
	INPUT TO AND OUTPUT FROM ALLOCATION TASKS							
	201 INPUT	202 INPUT	203 INPUT	204 INPUT	3.2.1.1.1 INPUT	3.2.1.1.2 INPUT	3.2.1.1.3 INPUT	3.2.1.3 OUTPUT
ALLOCATION AT WEAPON SYSTEM LEVEL								
ALLOCATION AT MAJOR SYSTEM LEVEL				FMEA data	Information flow analysis	Evaluation of human resources needs	Human alloc. for diagnostic functions	
ALLOCATION AT SEGMENT LEVEL	$\bar{R}$ modeling techniques	$\bar{R}$ alloc. drive FD/FI alloc.	$\bar{R}$ predictions for alloc. review	FMEA data	Information flow analysis	Evaluation of human resources needs	Human alloc. for diagnostic functions	analysis results
DEVELOP SUBSYSTEM DIAGNOSTIC REQMTS	$\bar{R}$ modeling techniques	$\bar{R}$ alloc. drive FD/FI alloc.	$\bar{R}$ predictions for alloc. review	FMEA data	Information flow analysis	Evaluation of human resources needs	Human alloc. for diagnostic functions	Task analysis results
DEVELOP ASSEMBLY DIAGNOSTIC REQMTS		$\bar{R}$ alloc. drive FD/FI alloc.	$\bar{R}$ predictions for alloc. review	FMEA data				Task analysis results

30. EXAMPLE OF DIAGNOSTIC REQUIREMENTS DERIVATION AND ALLOCATION PROCESS

This section clarifies the use of the requirements derivation and allocation process by providing a simple example of its application.

30.1 SCOPE. This example is limited to a simple weapon system so the interactions between steps of the RDA process may be readily illustrated.

30.1.1 Purpose. This appendix illustrates application of the requirements derivation and allocation process described in Appendix B.

30.1.2 Application. TBD

30.2. APPLICABLE DOCUMENTS. TBD

30.3 EXAMPLE. The example has been removed and will be updated for inclusion in future versions of this standard.

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APPENDIX C

40. FORMAT FOR INTEGRATED DIAGNOSTIC PROGRAM PLAN

40.1 SCOPE. The ID Program Plan can be applied to any weapon system acquisition in any phase.

40.1.1 Purpose. This appendix contains guidance for preparing an Integrated Diagnostics Program Plan (IDPP). This guidance is in the form of topics to be included in the IDPP. Evaluation criteria for guidance as to what constitutes an acceptable rendering of those topics is also included.

The IDPP is a coordinating and communication document between the contractor and the Government. It sets forth the contractor's proposed plan for conducting and managing the ID effort. It shows how the contractor intends to satisfy the requirements of MIL-STD-1814 as implemented by the contract schedule and/or statement of work. It also shows how the contractor intends to meet the imposed specification requirements, including their allocation and control to lower design levels.

40.1.2 Application. The information described in the following paragraphs should be documented for all programs in which diagnostics are of significance. It may be presented as part of the System Engineering Management Plan (SEMP), the Integrated Support Plan (ISP), or various other management plans. It may also be a stand-alone IDPP. The format offered in this appendix is suggested for a stand-alone document. It should also serve as an outline for information to address when incorporating the IDPP into a SEMP or ISP.

40.2 APPLICABLE DOCUMENTS. Not used

40.3 REQUIREMENTS. The requirements for an IDPP are as follows.

40.3.1 General requirements. The IDPP should describe in detail the specific techniques and tasks to be performed and their integration with other specified plans and contract tasks. At a minimum, the IDPP should address how the contractor will organize, manage, and achieve the ID requirements of each contracted phase. In addition, it should show how this activity could lead to the final ID capability in any following phases not under the current contract.

The IDPP should contain sufficient detail to establish that the contractor's process (including internal procedures, management and the extent of the planned application of this process) will satisfy all of the ID requirements.

The IDPP should be prepared and submitted as part of the contractor's response to the Request For Proposal. An update should follow the contract award to incorporate any negotiated contract changes. When approved, the IDPP should become a part of the governing contract. Subsequent revisions should be made only if significant program changes are negotiated.

The IDPP should consist of the following parts.

Part 1. Current policy and objectives
Part 2. Program summary
Part 3. Organization and interface requirements
Part 4. Task requirements

Part 5. Tradeoff and cost optimization
Part 6. Diagnostic requirements
Part 7. Validation/Verification requirements
Part 8. Vertical and horizontal integration
Part 9. Maturation
Part 10. Data
Part 11 Program schedule, data, and other deliverables

Overall evaluation criteria. The IDPP should provide sufficient detail to
a. Clearly identify the contractor's roles and responsibilities.
b. Show how all related parts fit together in a correlated program.
c. Provide a baseline from which changes in scope can be defined.
d. Identify all criteria for knowing when the objectives have been reached.

More specifically, is Part 1 stated in clear, unambiguous terms that are measurable?
Does Part 2 define the whole program and the relationships between deliverables?
Does Part 3 show an ID organization that has a management interface with Program Management?
Are solutions described to all requirements in Part 6?
Are trade studies scheduled sufficiently early to be meaningful?
Are schedules presented in Parts 4 and 11 compatible with each other and the overall program milestones?

40.3.2 Specific requirements. Specific requirements for an IDPP are as folows.

40.3.2.1 Current policy and objectives. Part 1 of the IDPP should describe the contractor's overall existing ID process as it relates to achieving the system design, development, test and evaluation requirements. This part should also address the extent to which ID has been institutionalized within the contractor's operating policies and objectives.

Evaluation criteria. Existence of Corporate policies indicates prior knowledge and planning related to the attainment of diagnostic objectives. Reference to existing, workable, and clearly worded policy statements, corporate directives, internal policies, etc, indicates some degree of experience and/or planning for diagnostics. Visibility of objectives that have been specifically set or tailored to the subject program demonstrate an understanding of the program at hand.

40.3.2.2 Program summary. Part 2 should describe the program objectives and requirements, prime mission system/equipment, the general maintenance concept to be used to support the system/equipment, and the contractor's approach to providing the required level of fault detection/fault isolation.

Evaluation criteria. Is a thorough understanding of the total program demonstrated including all related aspects of the maintenance environment.

40.3.2.3 Contractor organization and interfaces. Part 3 should describe the contractor's organization and internal interfaces required to perform the ID tasks. The plan should describe the processes used to ensure that integration of tasks is accomplished across all involved functional disciplines and that adequate feedback systems exist to redirect efforts to meet ID goals/requirements. Special note should be made of how data sharing plans will result

in a common data pool for all design activities. Where subcontractors, or teaming arrangements with associate contractors, contribute to satisfying ID requirements, describe the organizational interfaces and the planning and control functions to be implemented to ensure an integrated effort results.

A single individual should be identified who has overall responsibility and authority for implementing the ID program.

> **Evaluation criteria.** Does the organization demonstrate the ability to manage to the achievement of the ID requirements? Does the person who heads the ID program have equivalent leverage with the attainment of other requirements such as performance and cost? Is a workable data sharing plan described which involves all data developers and users?

40.3.2.4 Program tasks. Part 4 should describe the tasks to be performed to accomplish the ID program. ID program tasks should be portrayed to establish the hierarchical and sequential relationship between tasks. Direct correlation should be made to the contract work breakdown structure, if applicable. Describe the resources to be employed to accomplish each task required by the RFP. Follow-on tasks, scheduled in subsequent contract/development phases, should also be described.

Describe the interrelationships of ID tasks and activities and describe how ID tasks will interface and be integrated with other program tasks to avoid duplication of effort.

> **Evaluation criteria.** Are all tasks that are required by the Request for Proposal described sufficiently to show understanding, linkages, and dependencies? Does the implementation of each task described meet the objectives described in the earlier sections? Do the tasks defined adequately satisfy all aspects of the more broadly defined RFP task requirements?

40.3.2.5 Tradeoffs and cost optimization. Part 5 should identify expected trade studies to be accomplished and the proposed methodology. The methodology should include both the models and the data sources to be used. Trade studies planned/conducted should be documented to show how contractor derived requirements and solutions will result in cost effective achievement of the primary goals. Indicate planned tradeoffs in the master ID program schedule described in 40.2.8. Correlate the proposed trade studies to their associated tasks as described in Part 4.

> **Evaluation criteria.** Are tradeoffs described that are consistent with the program phase and design effort? Is the tradeoff methodology complete, unbiased, and workable in near realtime? Is feedback into the design process a reality?

40.3.2.6 Diagnostic requirements. Part 6 should describe how the performance requirements specified by the procuring agency are expected to be met by the contractors design. Also, describe the derived diagnostic requirements developed during the proposal effort and how they were obtained/allocated from the overall system requirements.

This section should cover separately the fault detection/fault isolation requirements for each piece of prime mission, support and test, and training equipment at all levels of maintenance as applicable to the subject contract.

Evaluation criteria. Are all requirements specified for the subject hardware addressed? Is justification provided for the approach selected? Have top level specified parameters been properly and completely allocated to lower levels so that the probability of attainment of the top requirements is near certain.

40.3.2.7 Validation/verification. Part 7 should define the contractor's plan to verify, demonstrate, and evaluate (VDE) the required level of diagnostic capability, including all proposed modeling, simulation, demonstration and field tests. Appendix D, 50.4, provides procedures and guidance for VDE activities and discusses relationships to the Maintainability VDE Plan and the Test and Evaluation Master Plan (TEMP). Ensure VDE covers all diagnostic needs (mission, safety, and maintenance).

Part 7 should also define in-process reviews and other quality control activities planned. Described in-process activities should ensure a high probability of success when the end of the activity is reached.

Evaluation criteria. Are the validation/verification requirements of the RFP completely and clearly described without unnecessary test redundancy? Are the described test sample and resources sufficient to provide the required confidences and risks? Is it convincing that described in-process reviews are sufficient to ensure success at the task's end?

40.3.2.8 Vertical and horizontal integration. Part 8 should define the approach and methodology for vertical and horizontal integration of diagnostics. Address integrating requirements across all diagnostic elements and maintaining test tolerance and diagnostic decision consistency between maintenance levels and dissimilar test equipments. Describe how such consistency will be demonstrated for factory, on-hardware, intermediate and depot testing specifications, procedures, and software programs.

Evaluation criteria. Is a feasible mechanization presented to ensure vertical and horizontal integration? Does the plan include feedback and corrective action methodology for dealing with early field experience?

40.3.2.9 Maturation. Part 9 should describe, in detail, a structured plan for evaluating the as-to-be-deployed diagnostics in an operational field environment, correcting any deficiencies in the diagnostic design noted during field operations, and incorporating those corrections in all production items. Part 9 should include the following.

a. Expected achievements (goals) from maturation
b. Identification of resources to be used
c. Planned contractor and customer organizational involvement
d. A schedule of all phases of the maturation effort, such as data gathering, analysis, redesign, retrofit and new production
e. Data collection and analysis methods
f. Retrofit methods and plans if required
g. Maturation activities conducted as part of interim contractor support

Maturation planning should be started early and accomplished to the extent applicable even though field maturation is not a part of the program phase being proposed. Plans for early program phases should address how efforts in the current phase can lead to an adequate maturation program in subsequent phases.

Evaluation criteria. Is the described maturation plan consistent with all other program planning and resource availability? Does it provide the necessary depth and scope to achieve the established goals? Does the timing provide for feedback prior to a significant production commitment? Does the plan include feedback and corrective action methodology for dealing with early field experience? Are the proposed benefits realistic and consistent with the remainder of the plan?

40.3.2.10 Data. Part 10 should describe data to be provided by the contractor to meet contract requirements, including approval requirements. Address data elements, such as failure modes and effects analyses, test requirements documents, acceptance test specifications, logistics support analysis documents, technical manuals, system and subsystem hardware, and software development and operational test and evaluation planning documents.

Evaluation criteria. Does the plan describe how all ID data requirements of the RFP will be supplied and the source of the information for each data item? Will the data as described be complete, accurate, timely, and not conflicting with other data items?

40.3.2.11 Program schedule of ID tasks, data, and other deliverables. Part 11 should provide a schedule for each of the tasks described in 40.2.4 above and each data item described in 40.2.10 above. The schedules should be presented in a manner that shows time phasing and interrelationships of the tasks and data. An overall master milestone schedule should also be presented to reflect key activities and events during each program phase, to ensure that final system requirements are met.

The schedule must be tied to the System Engineering Master Schedule (SEMS) events and should be prepared under SEMS ground rules. Criteria should also be identified for each task in the schedule that describes by what means the task will be considered complete.

Evaluation criteria. Are schedules feasible with some slack time to recover from inevitable slippages? Are all data sources available at the time required to meet the data submittals? Are all interdependencies reflected correctly in the schedule? Is the criteria which defines task completeness practical, measurable and sufficient?

APPENDIX C

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APPENDIX D

50. QUANTIFICATION OF DIAGNOSTICS IN WEAPON SYSTEM DESIGN

If rational decisions are to be reached regarding the role of integrated diagnostics in a weapon system design, it is necessary to provide quantitative means for evaluating the costs and benefits of the diagnostics relative to the goals of the weapon system. This appendix sketches a process for quantifying the diagnostics and discusses related issues of validation and verification of the diagnostic design and design phase dependence.

50.1 SCOPE. This appendix provides a rough outline of the process to be used to derive diagnostic accuracy requirements from the weapon system Statement of Operational Need (SON). It is expected that the details of the process will vary from application to application and that the tools used to carry out the process will frequently be developed by the contractor as proprietary technology. The examples presented in this appendix are deliberately simplified to avoid use of proprietary technology and in order to focus attention on the diagnostic aspect of the process.

The emphasis of this appendix is on diagnostic accuracy, even though accuracy is only one of the quantifiable attributes associated with diagnostics. Other parameters that need to be considered as part of the diagnostic quantification are diagnostic coverage, mean time to diagnose, cost, weight, etc.

50.1.1 Purpose. This appendix answers the following four questions concerning the development and implementation of diagnostics for weapon systems:

1. How are diagnostic accuracy requirements derived from the weapon system level metrics that are included in high level requirements documents such as the SON or the System Operational Requirements Document (SORD)?

2. How do detail designers achieve the diagnostic accuracy requirements that are allocated to their weapon system component?

3. How is the achievement of diagnostic accuracy requirements validated and verified?

4. How do the answers to the questions given above change during the program life cycle (from Concept Exploration Phase through Deployment)?

These questions are answered somewhat sketchily because detailed answers will vary from weapon system to weapon system. The goal of this appendix is to provide sufficient definition so that the user can adapt the methods described here to solve a specific problem.

50.1.2 Definitions and Abbreviations

CND (Cannot Duplicate). An operationally observed/recorded system malfunction that maintenance personnel are unable to duplicate at the Organizational Level.

False Fault. An event that consists of the reporting, by the diagnostic system, that a fault has occurred, when the fault has really not occurred.

Fault. A physical condition of a component or system that results in the failure of that component or system to carry out one or more of its essential functions.

FMECA (Failure Modes, Effects and Criticality Analysis)

Hit. An event that consists of the reporting, by the diagnostic system, that a fault has occurred, when, in fact, that fault has occurred.

Miss. An event that consists of the failure by the diagnostic system to report that a fault has occurred, when, in fact, that fault has occurred.

ReTOK (ReTest OK). A unit that is identified as malfunctioning at one maintenance level, but fails to exhibit the same malfunction at a subsequent maintenance level. (Also RTOK)

Validation. The act of comparing a model to a set of relevant data, or to established physical principles, to evaluate the correctness and completeness of the model for the situation under study.

Verification. The act of carrying out a test sequence, analysis or some equivalent procedure to determine that a stated requirement has, or has not, been satisfied by a given design.

50.2 APPLICABLE DOCUMENTS.

(NOTE: These documents are not to be applied contractually except to the extent that specific portions are cited in the requirement statements or verification statements.)

50.2.1 Government documents

50.2.1.1 Specifications, standards, and handbooks

MIL-STD-471A	Maintainability Demonstration

50.2.1.2 Other Government documents, drawings, and publications.

AFR 80-14	Research and development Test and Evaluation
DoDD 4245.7-M	Transition from Development to Production
DoDD 5000.3	Test and Evaluation

50.3 DERIVATION OF DIAGNOSTIC ACCURACY NEEDS. The "design quantification" process begins with the establishment of one or more models that express SON metrics in terms of design parameters. Most engineers in the aircraft industry have some familiarity with aircraft or engine performance models that achieve this purpose. Many engineers are also aware of Life Cycle Cost models (or sub elements thereof) and of reliability models that address other SON metrics. Full design quantification requires that all quantifiable parameters from the SON be modeled in terms of design variables. If diagnostics is to be used to carry out the design intent, then the diagnostic metrics must be included in the SON models.

Diagnosis of weapon systems problems is accomplished through use of a number of different techniques. Many problems may be detected and/or isolated through use of Built In Test (BIT). This technique is especially common for electronic systems. Often, one or more sensors may be used to derive the health of a component. Such derivation might be accomplished in onboard software or after the flight, using ground based systems. Ground based systems frequently make use of trending to recognize the onset of a problem. Still other

problems are recognized during periodic inspections either visually or through use of support equipment. Support equipment may also be used to isolate problems that are detected during flight. Yet another technique that is used for diagnosis involves manual resolution of the problem. In this case, a maintenance manual or "Tech Order" (T.O.) describes the procedure to be followed. If all other methods are unavailable (or sometimes for other reasons) the diagnostician may use selective parts replacement as a diagnostic technique.

The development of diagnostic accuracy requirements must cover each of the above diagnostic techniques. Diagnostic accuracy has just as much meaning when applied to manual techniques driven by a T.O. as it does when applied to built in test. Both techniques are subject to human frailties in their application, as well as other classic error sources. The derivation of diagnostic accuracy requirements must be data driven, in order to succeed, because of the human element. It is tempting to include only those error sources that are well understood and readily modeled, but this approach is sure to fail because the more difficult to model error sources are generally the most significant.

It is also important to note that diagnostic accuracy is inextricably linked to other parameters in the analysis. For example, if diagnostic coverage is reduced, there are a greater percentage of problems to be solved by arbitrary change of modules. For problems that are extremely rare or which can obviously be traced to a particular module, this may be acceptable. However, in general, as diagnostic coverage is reduced, diagnostic accuracy is likely to decrease as well. Another factor which should be considered is the time available to perform the diagnosis. As this time is reduced, the mechanic is forced to make a decision with less information. In the extreme, the mechanic is forced to change a module based on instinct rather than reasoned isolation. This, again, will decrease diagnostic accuracy.

In some instances, an element of a weapon system cannot be permitted to fail because it is critical to flight safety. (Actually the failure rate must be extremely low; a zero failure rate is unachievable). Various techniques are available to address this problem. The most common is to adopt a very conservative policy towards the replacement of a component that calls for it to be replaced long before it is likely to fail. This approach is commonly used for critical propulsion system components. Electronic systems that are critical are frequently designed with redundant copies, so that if one system fails, another copy can pick up the load. Reconfigurable systems are also sometimes employed in this mode. These deviations from the normal design process must all be considered when executing the diagnostic design and its associated modeling.

Figure 12 shows a view of the process that is proposed for the derivation of diagnostic requirements. The source of the highest level requirements may be a SON, a SORD, a Statement of Work (SOW) or some contractual agreement between a contractor and a subcontractor. In the figure, this highest level requirements source is illustrated as being a SON. Many of the requirements expressed in this document are quantifiable. Some typical examples are shown in Figure 12 and a more complete list of potential parameters is provided in Table 5. For each of the quantifiable parameters identified in the SON (or other source document), a model which is capable of predicting the values of the parameters using design variables as inputs should be generated.

APPENDIX D

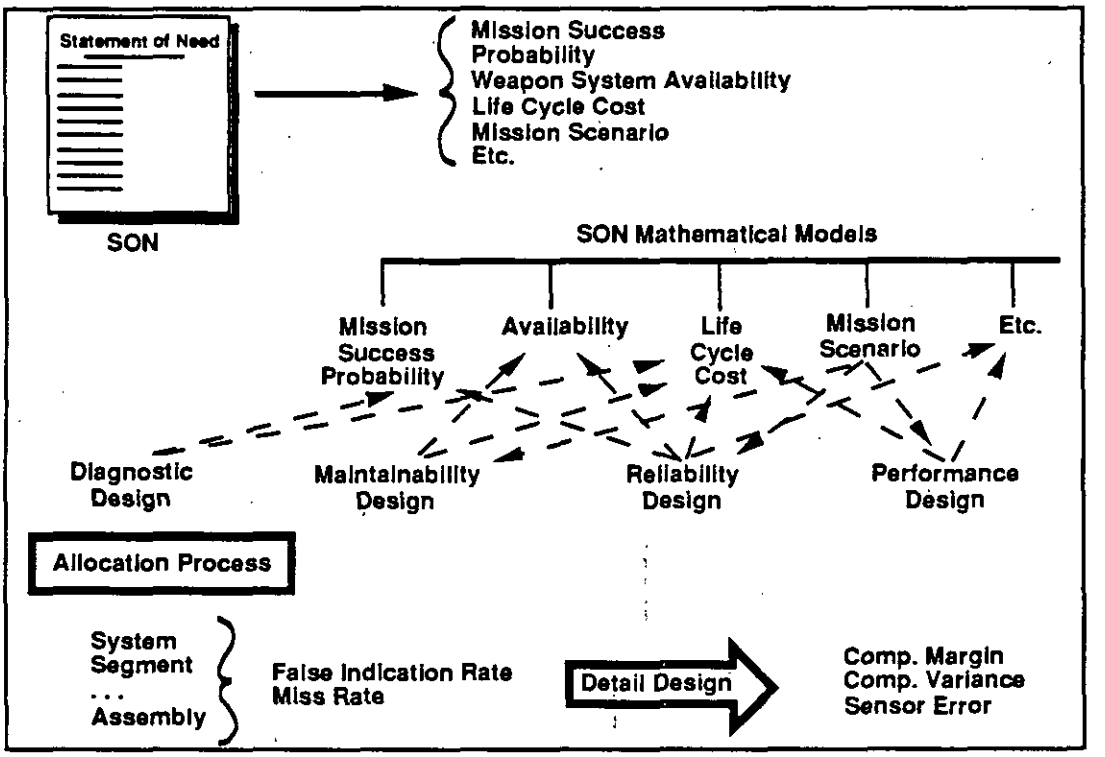

Figure 12 Diagnostic Accuracy Design Process

Table 5 System Level Performance Metrics

Life Cycle Cost	Accident Rate
Development Cost	Incident Rate
Production Cost	Sortie Rate
Support Cost	Time to Launch
Mission-Success Probability	Maintenance Delays
Availability	On-Time Takeoff Rate
Turn Rate	Supply Delays
Maintenance Man Hours per Flight Hour	Break Rate
Maintenance Concept (2 or 3 Level)	Fix Rate
Mean Time to Repair	Support Equipment Requirements
ReTest OKs	Mobility/Airlift Restrictions
Bench Check Serviceables	Mission Scenario
Can Not Duplicates	Manpower, Personnel, and Training
Crew Size	Survivability
Skill Level	Size and Weight Restrictions
Ambiguity Group Limit	Testability
In Commission Rate	Hardware Reliability
Mean Time to Diagnose	Configurability
Abort Rate	Reconfigurability
Safety and Mishap Rates	Fire and Forget Capability

Performance models are regularly generated for this purpose. For example, a propulsion system cycle model is capable of predicting thrust, fuel flow and other performance parameters as a function of propulsion system design variables. These propulsion system models are

linked to airplane models to predict aircraft performance, fuel usage, etc. with the additional input of airplane design parameters.

A life cycle cost model is another type of model that is used to predict high level figures of merit from design parameters. These models are substantially different from the performance models described above; yet, they serve the same type of role in the design process. Operational effectiveness models of various types are yet another example of a model used to relate design variables to weapon system level figures of merit.

The underlying purpose for generating and maintaining these models is to permit the performance of trade studies to evaluate various design solutions to satisfy the statement of need. Thus, the various elements of the design that are being considered as possible solutions must be included in the models. This appendix suggests the addition of diagnostics so that it can be evaluated against other schemes for achieving the design goals. Clearly, some of the individual weapon system goals can be accomplished in more than one way. For example, availability can be achieved by high reliability, or at a lower reliability level with excellent diagnostics coupled with rapid maintenance procedures. One or the other of these solutions may recommend itself on a cost basis. This is the type of trade study that is carried out to evaluate alternate design solutions.

If trade studies involving diagnostics are to be accomplished, then diagnostic design parameters must be included in the requirements models. A subsequent paragraph of this appendix illustrates the addition of diagnostics to a mission model. At this level of the design, it is proposed that diagnostic accuracy be expressed in terms of "false faults" and "misses." A subsequent step will convert these measures into more fundamental diagnostic design parameters (sensor accuracies, etc.). The models may be based either on observed empirical relationships between the design variables and the weapon system metrics, or on a physical understanding of the relationship. The physically derived relationship is preferable, but cannot always be achieved.

Once the higher level trade studies have been completed and the values for false fault rate, miss rate, etc. have been derived, allocation to lower levels of the design is accomplished through the use of more detailed models. Clearly, the false fault rate (expressed as number per flight or in some similar manner) for the weapon system is the sum of the false fault rates for all of its elements. Thus, the use of more detailed models permits a partition of the false fault rate among the various weapon system components in a manner that achieves the high level metrics. In some cases, trade studies that evaluate various approaches to meeting SON figures of merit will be repeated at the component level. This might be done to trade off diagnostics against reliability, as an example. These lower level trade studies must be traced back to the top level to confirm the achievement of SON metrics.

The allocation process will continue down to the smallest elements of the weapon system, where it should be possible to evaluate the allocated requirements against past experience for any component. This reference to prior experience may be modified to reflect the insertion of new technology. At this lowest level, it should be possible to confirm that the allocated requirements can be achieved, or, failing this, to consider design changes that may lead to their accomplishment. In any event, the results of this analysis should be added to the system of allocation models so that the details may be accumulated to confirm the achievement of the SON figures of merit.

The results of this process can only be as reliable as the data that are the basis of the estimates for the model. Thus, it is important that the participants in the design process have access to relevant data from other designs so that the model estimates will, as far as possible, be based

on sound empirical evidence. Appendix F of this document describes the type of information that should be available in a data base in order to support this type of allocation process.

50.3.1 Example of mission model adapted to include diagnostics. It is not the intent of this appendix to fully define the techniques to be used to add diagnostics to the weapon system Statement of Operational Need (SON) models. However, the techniques are sufficiently new that an illustration of their addition to a particular model seems to be in order. A relatively simple, top level, mission effectiveness model has been chosen for this purpose. A simple model was selected to emphasize the diagnostics representation rather than mission effectiveness modeling issues. The techniques that are described here are equally adaptable to more sophisticated models.

Mission effectiveness is almost certain to be addressed in a weapon system SON or other source document. For example, for an offensive weapon system, the number of target kills in some established time period, based on defined starting resources, is likely to be expressed in some form in the SON. Mission effectiveness models are used to predict such parameters from design variables in order to facilitate trade studies between proposed designs with regard to their "kill effectiveness".

Diagnostic performance attributes are generally not included in mission effectiveness models at present, regardless of sophistication. A possible exception is general measures such as CND's. Any general diagnostic figures of merit that are included are likely to be empirical so that they do not reflect the diagnostic design. Thus the current models cannot be used to evaluate the benefits associated with effective diagnostics. It is essential that the models have the capacity to reflect the actual diagnostic design so that meaningful trades can be made to evaluate diagnostics as a design solution. (Empirical models may, however, be useful to establish initial goals for the diagnostic system).

The model to be used for the present discussion addresses a scenario where a fixed number of aircraft are deployed to a remote location together with sufficient logistic support to provide some level of repair capability. Available aircraft fly sorties at some frequency for a given number of days with the objective of achieving a specific type of strike against the enemy. Each successful strike is designated a "kill". The aircraft are subject to attrition either as a result of enemy action or due to the malfunction of a critical subsystem. The aircraft are also subject to incurring malfunctions that increase their vulnerability to enemy action and/or reduce their likelihood of achieving their mission.

The details involved in the physics-based prediction of the influence on loss and kill rates of weapon system design parameters and of system malfunctions does not directly impact diagnostic questions. For present purposes, it will be assumed that these details are generated using the individual weapon system's single mission simulation. The focus of the present analysis is the addition of diagnostic parameters to the mission effectiveness model. Specifically, two attributes of the diagnostics system will be added to the mission effectiveness model:

> **Hit Rate** represents the fraction of weapon system malfunctions that are detected and enunciated correctly by the diagnostic system. The assumption is made that the enunciation of the fault will lead to an appropriate response by the recipient. The compliment of hit rate is "miss rate", which refers to faults that are not enunciated.
>
> **False Fault Rate** represents the fraction of diagnostic system fault enunciations which are incorrect in the sense that they induce the recipient to respond to a fault that has not occurred.

Note that it is possible that an event would simultaneously add to the miss rate and the false fault rate when the diagnostic system correctly indicates that a fault has occurred, but incorrectly diagnoses the fault, leading to an inappropriate response by the recipient of the enunciation.

The addition of diagnostics should increase the effectiveness of the weapon system by reducing the impact of malfunctions on weapon system performance. Thus, when malfunctions are detected that could place the weapon system at risk, the mission can be scrubbed to avoid costly losses. Similarly, the detection of a fault which jeopardizes the ability of the weapon system to achieve its mission (kills) could lead to scrubbing of the mission to avoid unnecessary risk of loss due to enemy action when the mission cannot be successfully achieved. Both of these actions should reduce the loss rate, and, as a secondary effect, increase the kill rate (due to more aircraft being available for later missions). These benefits are offset by the adverse impact of scrubbing missions that were likely to be successful due to the enunciation of false faults by the diagnostic system.

To make these benefits quantitative, it is necessary to evaluate the impact of the hits and false faults on the loss rate and the kill rate. Diagnostic system hits will reduce the loss rate due to the avoidance of enemy action and of malfunction induced losses. False faults will also reduce the loss rate for a fixed squadron size by reducing exposure of the weapon system to enemy action. (The penalty associated with false faults is that a larger squadron is needed to achieve a given mission). The kill rate per completed sortie should increase due to the elimination of those weapon systems with defective offensive armaments.

This discussion suggests the addition of some parameters to capture the affect of diagnostics on the weapon system's mission effectiveness. These parameters are as follows.

Fraction of Weapon Systems Continuing Sortie Given Enunciated Fault Not all faults will lead to the scrubbing of the mission. In some cases, the decision will be reached to continue the sortie at a higher risk.

Loss Probability Increase Given Malfunction The existence of a malfunction will, in many cases, increase the risk of weapon system loss. The sortie might continue either as a result of a miss (failure to detect the malfunction) or due to a decision to continue despite an enunciated malfunction.

Degrade in Kill Effectiveness Given Malfunction *In most instances, the* presence of a malfunction will reduce the effectiveness of the weapon system to achieve its primary mission. The sortie might continue either as a result of a miss (failure to detect the malfunction) or due to a decision to continue despite an enunciated malfunction.

The special diagnostic inputs and the other standard inputs to the mission effectiveness model are summarized in Figure 13.

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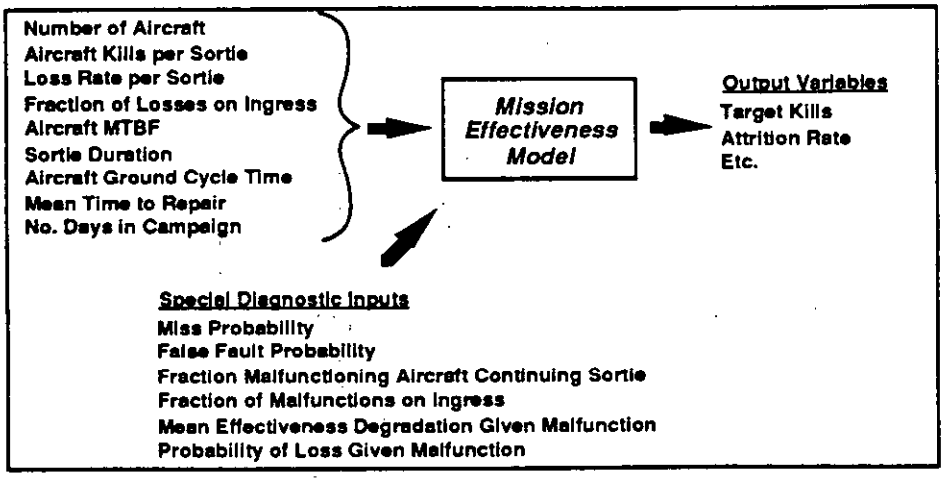

Figure 13 Mission Effectiveness Trade Studies for Diagnostics

The ability to accurately predict these parameters implies a more in depth knowledge of the design (i.e. of the Failure Modes, Effects and Criticality Analysis) than is available in the simple model that is being developed here. These parameters may be estimated for preliminary analyses from prior experience. It is likely that the parameters will vary as a function of diagnostic coverage. In fact, the diagnostic design should emphasize those areas of maximal payoff; hence, there is likely to be a "law of diminishing returns" at work as diagnostic coverage becomes more complete.

During the early stages of the design process, the knowledge of the weapon system is likely to be expressed in terms of functional elements. The means of achieving these functions generally will not be determined. However, the role that each functional element plays in achieving the mission of the weapon system should be understood. As a consequence of this knowledge, it should be possible to estimate the impact of losing the functionality. In particular, it will be possible to approximate the impact of the lost functionality on the ability of the weapon system to carry out its mission, and to achieve a safe return to base. The results of these analyses will provide a first indication of whether the loss of the functionality will result in scrubbing the mission.

In the absence of a firm design, it will be difficult to accurately estimate the probability of losing the function. However, prior experience may be used to provide an estimate. In fact, the specification of reliability rates should be occurring at the same time as part of the reliability and maintainability analyses. This reliability information provides the failure frequency required for the diagnostic analysis.

At later design stages, the design implementation of the desired functionality should be specified. At this point, the emphasis turns toward the physical implementation of the functional design. The functional data are still used to address question such as the scrubbing of the mission and the impact on loss and kill rates. However, the malfunction frequencies should be driven by prior experience with similar hardware, or current available test experience. Design solutions in critical areas may include redundant or reconfigurable systems, or diagnostics. The availability of the detailed design should help in estimating the effectiveness of the diagnostics (hit rate, false fault rate) as a design solution.

The results of these detailed analyses may be reintroduced into the mission effectiveness models to evaluate the attainment of weapon system level requirements as expressed in the

SON. As indicated, the quality of the information should improve as the design proceeds. The data acquired during the "functional" phase continues to be useful as the design enters the "physical" phase for indicating impact on weapon system effectiveness.

An example of a detailed mission model analysis, including diagnostics, is provided in attachment A.to this Appendix. Some typical results of the analysis are shown in Figure 14.

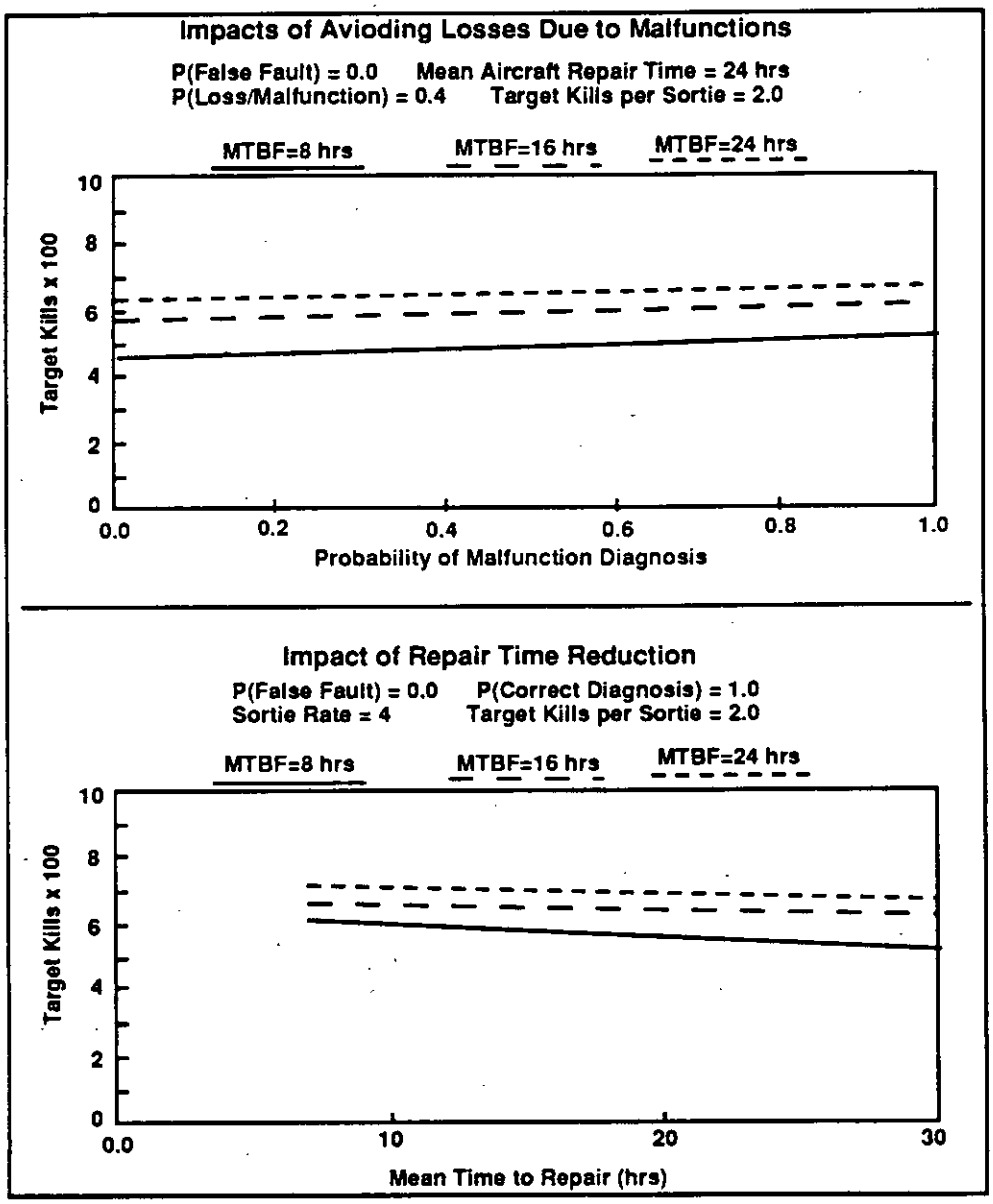

Figure 14 Sample Output from Mission Model with Diagnostics

50.4 SATISFACTION OF DIAGNOSTIC REQUIREMENTS. Once requirements for diagnostic accuracy have been established, it is the job of the diagnostic designer to select measurement devices that will achieve the desired accuracy specifications. The requirements are apt to specify figures of merit such as hit rate, miss rate or false fault rate. The designer is

more likely to be able to select sensors that provide a specified accuracy or repeatability. Thus, there is a need to translate the requirements to a form that can be used to specify hardware or software. As will be shown in this portion of the appendix, this translation involves the development of an additional mathematical model.

Perhaps the simplest analytic case to be considered is where a component has a single performance limit which is amenable to direct measurement. In this case, the component is concluded to be serviceable if the performance measurement lies below the limit, and the component is judged to be faulted whenever the measured performance exceeds the limit. If the sensor used to determine the performance of the component were perfect (no error), there would be no false faults or misses. The occurrence of false faults and misses in this case results from the sensor error. (Note that for more complex examples there can be other sources for diagnostic errors such as faulty assumptions in the component performance model.)

Figure 15 exhibits the occurrence of a miss for an imperfect sensor. In Figure 15, the sensor is assumed to be without bias; hence, the peak of the sensor error distribution is taken to be the true value of the performance parameter for the component. In Figure 15, this true value lies above the limit; thus, the component should be judged to be faulted. However, as indicated by the shaded area in the figure, there is a non-zero probability that the component will be judged to be serviceable even though the performance is in the failed regime. The figure graphically shows the probability of a miss given that the performance is located at the precise value shown. To determine the composite miss rate, it is necessary to consider every possible value for the component performance, as suggested by the component variation curve in the figure. Note that only those cases where the true performance is in the faulted region can lead to a miss.

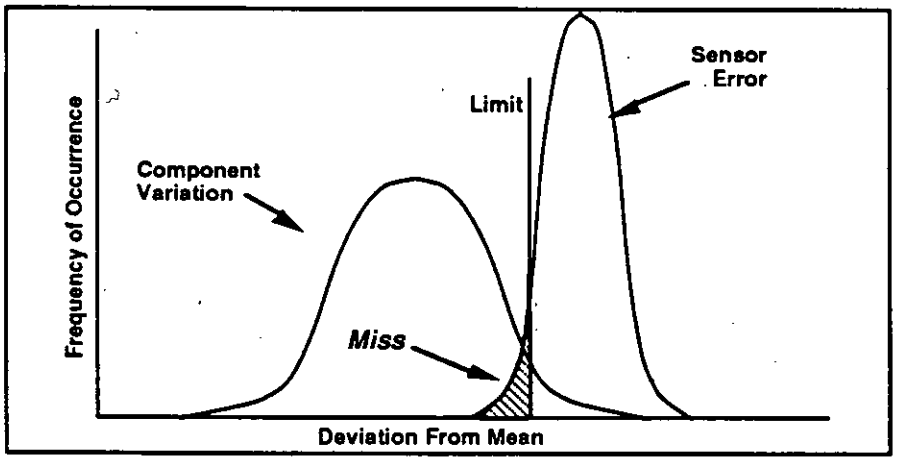

Figure 15 Diagnostic "Miss" Illustrated for One-Sided Test

Using the model of figure 15, the probability of a miss can be expressed as:

$$p_m = \int_{x_1}^{\infty} f_c(x) \left\{ \int_{-\infty}^{x_1 - x} f_s(y)\, dy \right\} dx$$

where

p_m = Probability of a "miss"

x = Value of measurement used to judge go/no-go status of a component

f_c = Probability density function for component variation

f_s = Probability density function for sensor error

x_l = Limiting value of "x" for the component

Figure 16 illustrates the analysis of a false fault for the same model. A false fault can occur only when the true performance lies within limits. The mean of the sensor distribution in Figure 16 is indeed within acceptable performance bounds. However, there is some probability of a false fault for this example, as suggested by the shaded area. Once again, it is necessary to consider all possible levels of component performance, together with their relative likelihood, in order to compute the probability of a false fault. The equation that represents the false fault probability for figure 16 is:

$$p_f = \int_{-\infty}^{x1} f_c(x) \left\{ \int_{x_1 - x}^{\infty} f_s(y)\, dy \right\} dx$$

where

p_f = Probability of a "false fault"

The detailed mathematical analysis for this simple model is demonstrated in Attachment B to this Appendix.

Note that the addition of a two sided limit, or of measurement bias (perhaps with its own probability distribution) does not add to the complexity of the analysis, although it does complicate the interpretation of the results. Figures 16 and 17 suggest the use of the Gaussian (or Normal) probability distribution. Frequently, the assumption of a Gaussian distribution proves to be a poor approximation in practice. In these cases, the appropriate distribution may be used for the analysis in place of the Gaussian distribution (see Attachment B), and the resulting integrals may still be evaluated (probably via numerical techniques).

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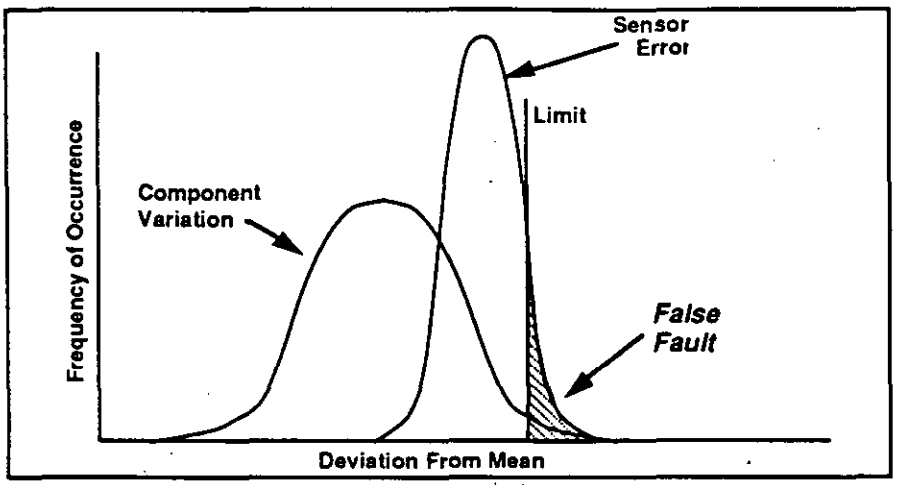

Figure 16 "False Fault" Illustrated for One-Sided Test

Design engineers should not be asked to perform the statistical analyses that are outlined in Attachment B. Instead, they should be supplied with design rules or curves such as those shown in Figures 17 and 18. The actual curves shown in Figures 17 and 18 are derived using the simple model of Figures 15 and 16. More sophisticated models may lead to different curves, but the design approach is similar. Figures 17 and 18 may be used to identify a combination of component margin, component variability and sensor error that yields sufficiently small values for false fault rate and miss rate. Often, the component margin and variability will be more difficult to alter than the sensor error; hence, sensor error is most likely to be derived from the analysis. In some cases it may be necessary to increase component margin in order to achieve the desired false fault and miss rates.

Note that if the component is very reliable, the assumption that it never fails may satisfy the requirements for miss rate. In this circumstance, diagnostics may be discarded in favor of achieving weapon system goals through reliability alone.

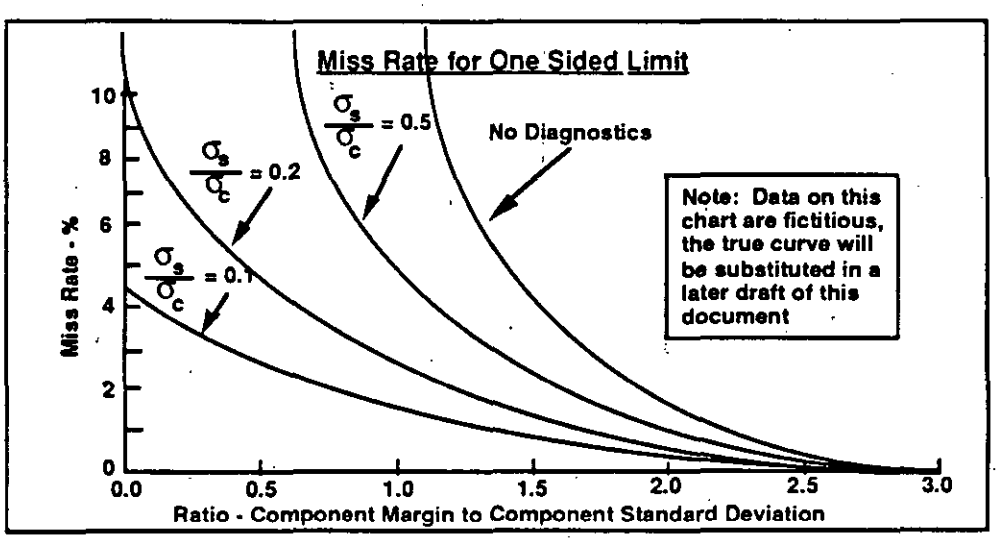

Figure 17 Example Design Chart for Miss Rate

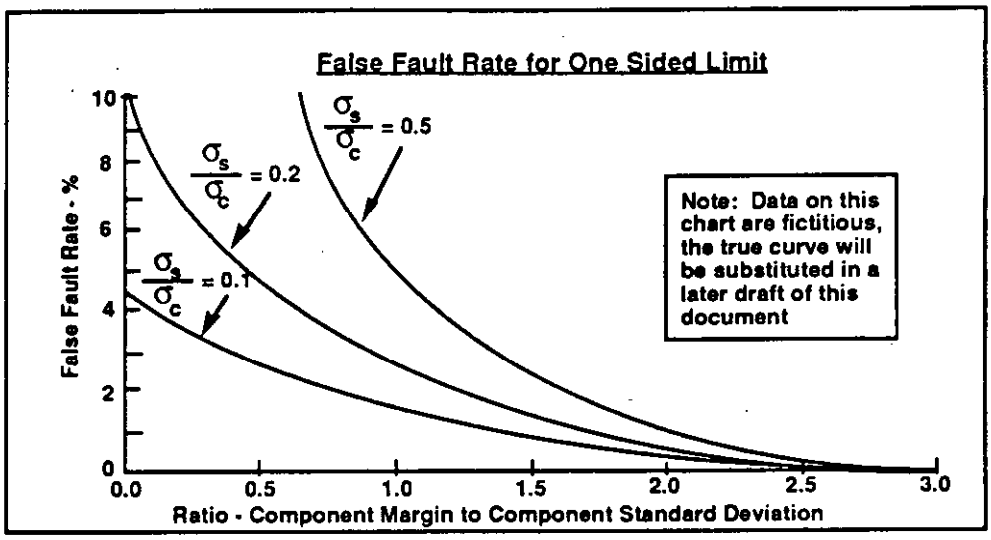

Figure 18 Example design Chart for False Fault Rate

It should also be noted that the relative magnitudes of false fault rate and miss rate may be adjusted by altering the limit with no change to component margin and variability or sensor error. Adjustment of the reject limit, without change to the system has the effect of trading false faults for misses. This strategy might be selected when one of the measures is met with significant margin while the other is being missed by a small amount.

The designer of Technical Orders or manual diagnostic techniques may be tempted to despair at the thought of meeting quantitative measures for diagnostic requirements. This despair is justified, given the current state of data available to reach quantitative decisions. However, it should be possible to develop workable strategies for improving manual repair techniques. A successful strategy might involve the following steps:

1. Categorize the problem areas associated with manual diagnosis techniques including specific root causes that frequently lead to false faults or misses.

2. Explore whether the use of support equipment or built in test might cost effectively improve the diagnostic capability.

3. If not, try to determine the specific problems that result in misses or false faults. This might be achieved through interviews of maintenance personnel following known incidents or calling on expert evaluation of these incidents.

4. Once problems in the procedures and/or documentation have been isolated, rework the faulted materials in order to eliminate sources of confusion or to add steps that correct the problems. If the problem appears to be one associated with the experience level of the personnel, expert systems might prove to be a solution.

5. If possible, verify the modified procedures or documentation by testing in actual service conditions.

In many instances, the detection or isolation of a fault is not accomplished via use of a single sensor. For example, jet engine component performance is normally deduced indirectly through use of pressure, temperature and other sensors. In this case, one or more algorithms

may be used to carry out the analysis. The algorithms will generally incorporate assumptions (e.g. that some potential fault mode is so rare as to be neglected) that include some uncertainty. When making use of one of the multi sensor algorithms, it is important to perform an appropriate study to properly reflect all of the error sources and their impact on the diagnostic accuracy. The potential error sources include the errors of the individual sensors, and also the potential errors in the assumptions.

It is also important to consider all sources of error for a specific sensor. A temperature sensor may do an excellent job of measuring the temperature at its particular location. Often, the temperature that is needed for the diagnosis is an average over some area, or at a location other than the precise location of the sensor. In this case, the error associated with the difference between the temperature being sensed and the desired sensor input must be included in the analysis. Frequently, this "displacement" error is the most significant element of the diagnostic error.

50.5 VERIFICATION OF DIAGNOSTIC DESIGN

50.5.1 Introduction. The specification of the diagnostic design is only the first step to ensure that the needed diagnostic capability has been achieved in the weapon system design. Carefully designed testing and/or analysis is necessary to prove that the elements of the design sum up to the required capability.

Normally, the highest level design requirements do not directly address diagnostics. Diagnostic requirements are, instead, derived from these highest level requirements. Thus, it would appear to be most desirable to eliminate diagnostics from the verification process in favor of the overall weapon system goals. Unfortunately, this is not practical due to the difficulty of obtaining satisfactory verification of the high level measures. To obtain adequate assurance that the weapon system achieves its goals, it is necessary to verify that the design elements perform according to their design requirements, and to validate the model used to derive these requirements from the high level weapon system requirements.

Even if this were not the case, it would still be desirable to acquire performance data for the diagnostic elements of a weapon system. This data is needed, as suggested above, during the design process, in order to project the capability of future diagnostic systems. The quality of the judgements reached in the design process is only as good as the data on which they are based.

The verification process is particularly difficult for the diagnostic elements of a weapon system. The principal reason for this difficulty is the relative scarcity of diagnostic events. Well designed weapon system components fail rarely and thus seldom call for use of the diagnostic system. Hence, extensive testing is required to be able to obtain a statistically significant evaluation of the diagnostic system. In many instances, the total experience of a fielded weapon system would not be adequate to evaluate the diagnostic system at a statistically significant level. Even special testing (with faults deliberately induced) may be precluded because of the prohibitive expense of such exercises (this is especially true for propulsion systems). This difficulty places an extra burden on the analytical approaches for diagnostic design verification.

50.5.2 Verification, demonstration and evaluation (VDE) of diagnostic design. For every diagnostic quantification method or metric there must be some way to verify, demonstrate, or evaluate that the method, or metric, is valid or has been achieved. The major stumbling blocks in achieving this goal are the fact that the diagnostic capability (or any element of this diagnostic capability) can fail in nearly an infinite number of ways and the

above mentioned difficulty in sampling a significant number of faults for evaluation. These make 100% verification, demonstration, and evaluation (VDE) impossible. A number of statistical and managerial methods have been developed to overcome these obstacles.

VDE for diagnostics is particularly difficult because of the many variables that must be addressed. Figure 19 depicts some of these variables and their interfaces. The VDE requirements for each category of diagnostic requirement (mission, safety and maintenance) varies depending on the operational and maintenance level and weapon system acquisition phase. Added to this are the variables for each diagnostic concept (fault detection, fault isolation and prognostics).

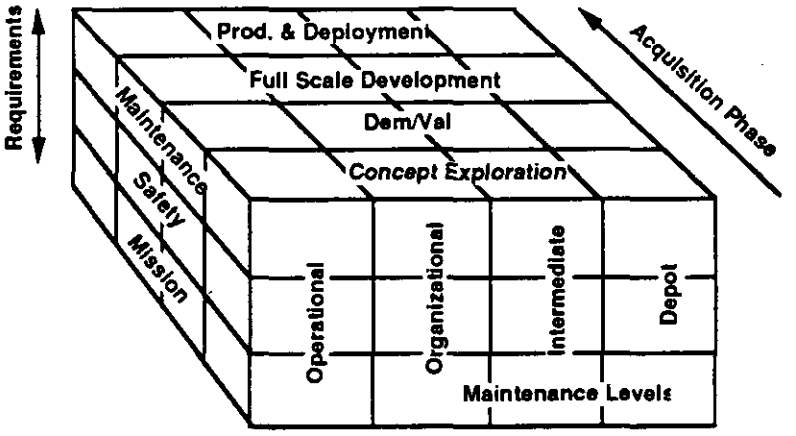

Figure 19 Verification, Demonstration & Evaluation (VDE) Interfaces

As noted previously, the principal quantitative diagnostic requirements (accuracy and time) vary with each design level (system through component). These quantitative requirements must also be specified for each diagnostic element (e.g. ATE/TPS, TOs, personnel, training). Thus VDE is required for the system's diagnostic capability as a whole, for each configuration item, and also for each diagnostic element that is part of this diagnostic capability.

All of these requirements and variables complicate the VDE job.

50.5.3 VDE procedures. Figure 20 is an example of the VDE requirements (see shaded boxes) that may be applied during a weapon system's development. Emphasis is placed on mission and safety requirements at the operational and organizational levels. Maintenance has broader application.

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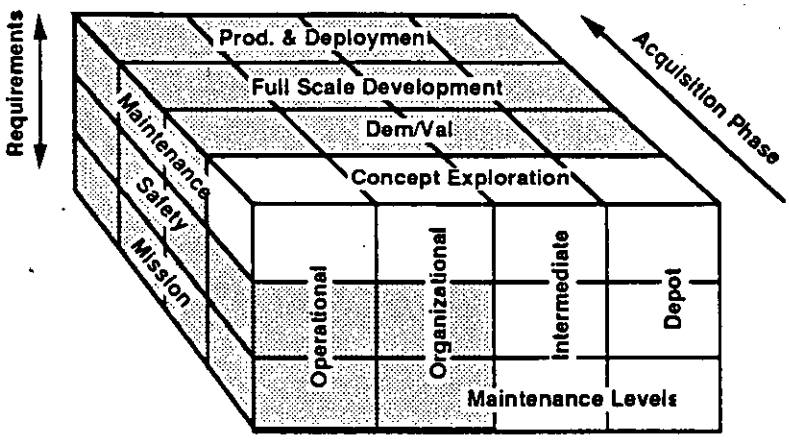

Figure 20 VDE Requirements

In general, Figure 21 depicts when verification, demonstration, and evaluation are applied in relation to life cycle VDE activities. The scheduling of these activities varies from system to system depending on needs. Presently, VDE for diagnostics is part of the following:

Maintainability demonstrations
Development Test and Evaluation (DT&E)
Operational Test and Evaluation (OT&E)

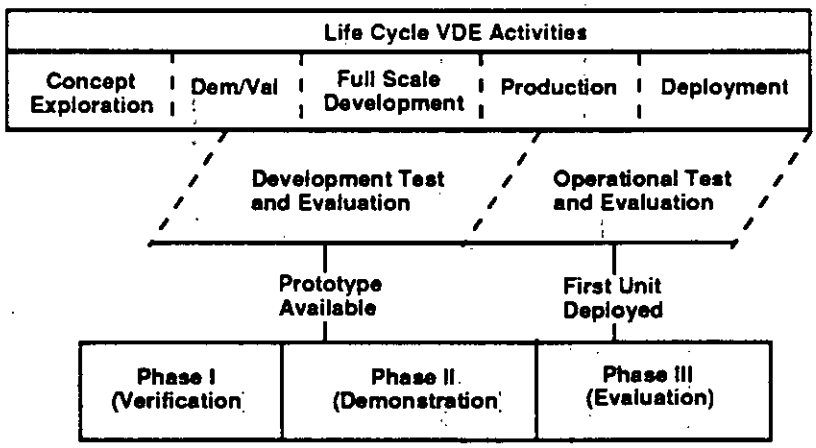

Figure 21 Life Cycle VDE Activities

Maintainability demonstration can be part of, or separate from, DT&E and OT&E.

Maintainability demonstrations are governed by MIL-STD-471A. Notice 2 of this standard is particularly relevant to diagnostics. This notice addresses procedures for demonstrating and evaluating equipment and system built-in test/external test/fault isolation/testability attributes and requirements. These procedures addresses fault detection, fault isolation and false faults, and calculate FD/FI rates, ambiguity levels and confidence levels along with reject/accept criteria.

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DOD Directive 5000.3, supplemented by AFR 80-14, provides policy and guidance for DT&E and OT&E. No specific guidance is provided in either document relative to diagnostics VDE. Thus, VDE for the diagnostic capability is accomplished as part of the overall system.

50.5.4 Guidance

50.5.4.1 MIL-STD-471A. MIL-STD-471A, augmented by Notice 2, is the basic document for diagnostic VDE for maintenance. However, there are some limitations to this standard that must be recognized. Descriptions of some of these limitations follow.

1. The standard does not address mission and safety requirements unless these requirements also involve a maintenance function. An example of this is the lack of VDE methods for fault tolerant systems. Therefore, it must be remembered that these requirements must be validated during other test and evaluation activities, mainly OT&E.

2. Table 3, Notice 2, of MIL-STD-471A breaks down fault isolation into three categories: built-in test, external special test subsystem, and manual procedures. If diagnostic requirements are further broken down into requirements for each diagnostic element (e.g. technical orders, portable maintenance aids, technical information delivery systems), then a further breakdown is required to accommodate these diagnostic elements.

3. Prognostics is not addressed except for calculations involving preventive maintenance times. Accuracy requirements are not addressed, thus requiring validation by using diagnostic performance data received from field operation.

50.5.4.2 Concurrent VDE. The overall diagnostic capability is the sum of a variety of diagnostic elements. Therefore, a requirement should be established for early demonstration of the entire diagnostic capability produced by the integration of all these diagnostic elements. This is referred to as concurrent VDE, where the timing of the various diagnostic element demonstrations and evaluations is planned and scheduled for concurrency, so that the entire integrated capability can be assessed.

Concurrency also applies to other VDE activities such as those conducted by the reliability, human engineering, and safety disciplines. Each of the disciplines plays a part in ensuring an adequate diagnostic capability. For example, false faults can be detected from field performance experience and also during reliability environmental stressing. Thus, diagnostic VDE must be considered as a part of the total VDE activities.

50.5.4.3 Maturation. The difficulty in 100% verification, demonstration, and evaluation of the diagnostic capability dictates a need for maturation of the diagnostic capability. This maturation period begins early in the diagnostic design process and extends well into deployment. This maturation period mandates the concept of diagnostic growth, similar to the already established concept of diagnostic growth. Figure 22 is a conceptual version of this growth process. First, goals must be established in SORD and specification requirements. Then, intermediate objectives should be established in each phase to reflect expected progress toward meeting these goals. Finally, VDE procedures must be employed to assess achievement of these objectives and goals. VDE procedures to ensure that these goals, or objectives, have been achieved in a given phase of the weapon system development must be tailored to a specific weapon system acquisition strategy. For instance, if the performance of an aircraft is to be evaluated at the conclusion of the Dem/Val phase, then the entire diagnostic capability should reach the specified requirement at that point in time. On the other hand, if only special units (usually high risk) of a weapon system are developed during Dem/Val, then

the diagnostic capability for only those special units may be demonstrated. In some cases, simulation may be required.

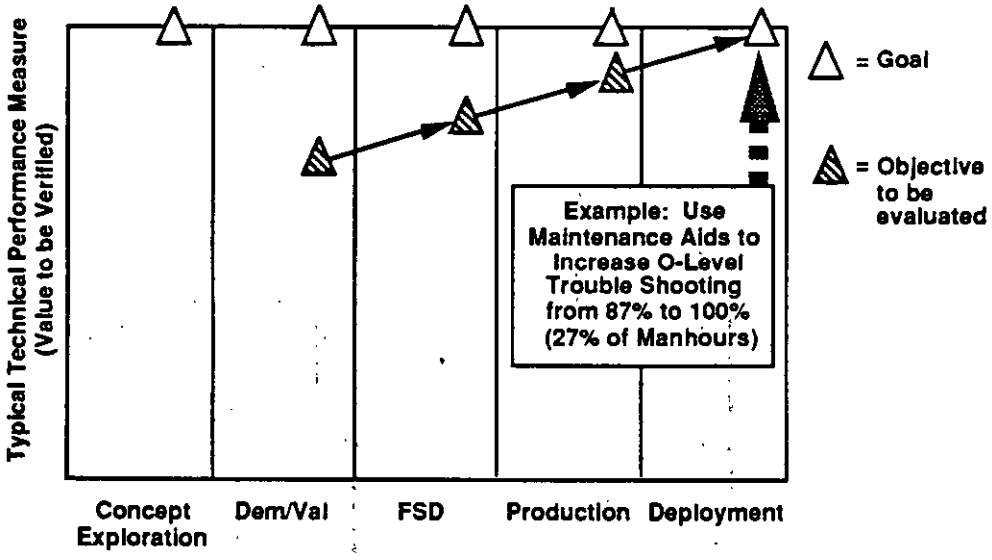

Figure 22 Diagnostic Growth Concept

50.5.5 VDE Planning Documentation. Presently, planning for VDE is incorporated into two documents. The first is a Maintainability VDE Plan (required by paragraph 4.2 of MIL-STD-471A) that essentially covers the planning for the three phases identified in Figure 10. The second planning document is the Test and Evaluation Master Plan (TEMP), which is required under DOD 5000.3, with guidance on its preparation contained in DOD 5000.3-M-1. Essentially, the TEMP applies to DT&E and OT&E activities. Care must be exercised to ensure that the concerns expressed in paragraphs 50.4.2 and 50.4.3 are addressed in the TEMP.

There are other VDE planning activities relating to reliability, human engineering, safety, and supportability. Portions of these activities are diagnostics related; thus, it is necessary to interface closely with these various plans.

In some cases, an Integrated Diagnostic Program Plan (see Appendix C) may be required. Parts 7 and 9 of this plan deal with validation, verification and maturation. The VDE issues cited above need to be addressed in this plan and reflected in both the maintainability VDE plan and the TEMP.

In an attempt to consolidate the VDE activities incorporated in the above plans, DOD Directive 4245.7 and its implementation manual, DOD 4245.7-M, suggest the preparation of an Integrated Test Plan (ITP). The ITP includes all development and qualification tests (prime contractors, subcontractors, and government) at the system and subsystem levels, identifies duplicate and missing test activities, and provides for the most efficient use of test facilities and test resources. The essential elements of the ITP are shown in Figure 23.

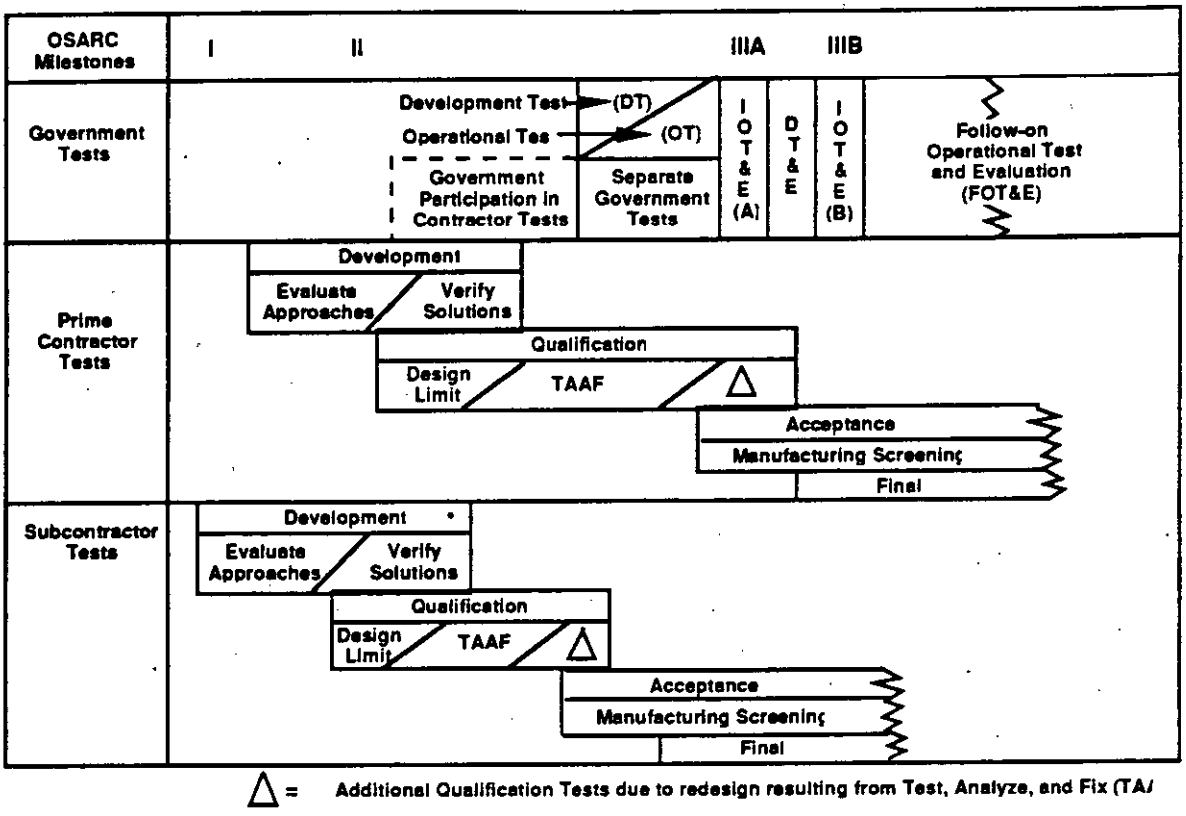

Figure 23 Integrated Test Plan

50.6 DESIGN PHASE DEPENDENCE. Major military weapon systems are usually designed in phases beginning with a Concept Exploration Phase and preceding through Dem/Val, Full Scale Development, Production and Deployment Phases. As these phases succeed one another, the information available to carry out the design becomes increasingly more detailed. At some point in the design evolution, hardware and software are available for testing and evaluation. Prior to this time, analyses of the design must be based on analogy from earlier similar designs.

To a very great degree, the information available defines the types of analyses that can be carried out. At the earliest stages, there is very limited data available concerning the implementation of the weapon system requirements. The form of this data is more likely to be a functional description of the system than a physical description. Even with this limited information, one can begin to assess the relative criticality of the various functions to the weapon system requirements. Each of the design disciplines is attempting a comparable appraisal in order to identify where effort is likely to be needed. In the diagnostics arena, the designer should be concerned with difficulties associated with previous designs for achieving the specific function, the availability of new technology for achieving the design, and lessons learned that may dictate design approaches. It is at this stage that the diagnostic designer can begin to identify the issues that will require the greatest attention during the design.

As the design precedes, details of the design will be developed in the various design communities so that the physical elements of the design can begin to be addressed. The criticality assessments from the earlier phases should still be valid. New data will include the FMECA (Failure Modes, Effects and Criticality Analysis) results. The availability of this

information allows the diagnostic designer to transition from a top down, functional point of view to a bottom up, physical point of view. Specific failure modes can be addressed in the diagnostic design and failure rate statistics can be used to improve the diagnostic allocation. The diagnostic designer should be especially looking for insertion of new technology into the weapon system design so that associated diagnostic problems can be identified and addressed.

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As demonstration or design hardware becomes available and testing is started, it is possible to accumulate experience on the performance of the diagnostic design. It is important to realize that these results are not statistically significant; however, they can be useful for detecting problems in the diagnostic design. It is extremely important to future design efforts that data be gathered on the effectiveness of the diagnostic design. This begins during the latter stages of the development cycle and continues through the production and deployment phases.

ATTACHMENT A

To be supplied at a later date

ATTACHMENT B

To be supplied at a later date

APPENDIX E

60. APPLICATION TOOLS

60.1 SCOPE. Tools discussed in this appendix help accomplish the ID process activities described in this standard.

60.1.1 Purpose. This appendix contains tools that assist in incorporating diagnostic requirements in acquisition programs or in complying with diagnostic requirements once they have been applied to a program.

60.1.2 Application. These tools are provided for use as desired. They are not mandatory program requirements and should not constrain users from employing other methods or from developing additional tools.

60.2 APPLICABLE DOCUMENTS

(NOTE: These documents are not to be applied contractually except to the extent that specific portions are cited in the requirement statements or verification statements.)

60.2.1 Government documents

60.2.1.1 Government documents, drawings, and publications

Fault Detection/Fault Isolation Allocation, Draft Final Technical Report for GIMADS Task 17, FZM-7542-2-5, TG2, 20 December 1990. For information contact ASD/AEGB-GIMADS, Wright-Patterson AFB, OH 45433-6503.

60.3 REQUIREMENTS CORRELATION MATRIX PARAMETERS. This section indicates how RCM parameters can drive diagnostic requirements. It should be useful in writing RCM parameters that lead to the desired diagnostic capability. It also indicates typical factors to consider when conducting analyses that breakout the diagnostic portion of these RCM parameters.

The following matrix lists RCM parameters that have diagnostic significance. Each parameter lists the diagnostic system-level requirements that are derived or constrained by this parameter and then the non-diagnostic design concerns that should be considered in determining what portion of the parameter should be assigned to the diagnostic requirement.

APPENDIX E

RCM PARAMETERS AND DIAGNOSTIC IMPACT

RCM Parameters (Operational needs)	System-Level Requirements Driven by RCM Parameters	
	Diagnostic-Related	Typical Non-Diagnostic Considerations
Man hours/sortie or flying hour	Mean time to diagnose False detections False isolations System checkout time Diagnostic mix SE operating speed	Servicing time Reconfigure time Periodic maintenance Other requirements
Manpower, personnel and training	Diagnostic mix Diagnostic human factors design criteria System checkout time Frequency of inspections Mean time to diagnose	Non-diagnostic training needs
Support mobility (C-141 loads)	Diagnostic mix SE size Diagnostic manpower Facilities Tech order structure	Non-diagnostic SE Munitions equipment Supplies and spares Personnel
Full/Partial mission capable rates	False detections and isolations Embedded fault coverage Fault reporting latency	Upper limit on break rates Time to repair Periodic maintenance time
Sortie generation rates	Mean time to diagnose System checkout time False detections and isolations Fault reporting latency SE operating speed Quantity of info. to be stored	Turnaround time Time to repair
Mission completion success prob.	Diagnostic mix Fault reporting latency False detections and isolations	Break rates
Criticality	Diagnostic mix Fault reporting latency	Break rates Reliability enhancements
Turnaround time	System checkout time Time to diagnose quick fixes Diagnostic mix	Servicing time Reconfigure time Quick fix time
Utilization rate	Diagnostic rates False detections and isolations Frequency of inspections Diagnostic manpower	Periodic maintenance Mission capable rate Time to repair Spares

APPENDIX E

RCM Parameters (Operational needs)	System-Level Requirements Driven by RCM Parameters	
	Diagnostic-Related	Typical Non-Diagnostic Considerations
Inflight engine shutdown rate	Embedded fault coverage Fault reporting latency False detections and isolations	Upper limit on engine break rate
Unscheduled engine removal rate	Embedded fault coverage False detections and isolations	Spares Break rates
Levels of maint.	Diagnostic mix Diagnostic human factors criteria	
Maint. concept	Diagnostic mix False detections and isolations	
Availability	False detections and isolations Quantity of info. to be stored Mean time to diagnose SE operating speed Diagnostic mix	Spares Break rates
Fix rate	Mean time to diagnose SE operating speed Diagnostic mix	Time to repair or replace
Break rate	Embedded fault coverage Fault reporting latency False detections and isolations Diagnostic manpower	Spares Reliability enhancements
Mission/Sortie length	Quantity of info. to be stored	Other storage demands
Operational system life	Frequency of inspections	
Quantity of systems	Frequency of inspection Diagnostic mix Facilities	Spares
Number of bases	Manpower Technical order structure	

APPENDIX E

RCM Parameters (Operational needs)	System-Level Requirements Driven by RCM Parameters	
	Diagnostic-Related	Typical Non-Diagnostic Considerations
Basing environment	System checkout time Frequency of inspections Mean time to diagnose SE size SE operating speed Diagnostic mix Facilities	
Acquisition cost	Embedded fault coverage Fault reporting latency False detections and isolations Quantity of info. to be stored	
Support cost	False detections and isolations System checkout time Frequency of inspections Diagnostic mix Facilities	
Life Cycle cost	Diagnostic mix False detections and isolations Quantity of info. to be stored System checkout time Frequency of inspections Facilities	Spares
Failure rate	Diagnostic mix False detections and isolations Quantity of info. to store down Frequency of inspections	Spares
Size and weight limits	Diagnostic mix Quantity of info. to be stored	Non-diagnostic components or sub systems
On-equipment power, processing	Diagnostic mix	

APPENDIX E

60.4 AVAILABLE TOOLS. There are many tools available to help managers and designers in designing and acquiring a weapon system's diagnostic capability. This section of Appendix E lists such tools and indicates what functions they perform, how they can be applied, how they can be acquired or accessed, and how they relate to the diagnostic activities in the Roadmap and related requirements in this standard.

60.4.1 Application. Tools in this section are organized under the following four categories.

1. Deriving and allocating diagnostic requirements
2. Designing the diagnostic capability
3. Assessing the performance of the diagnostic capability
4. Maturing the diagnostic capability

Table 6 depicts the functions (subcategories) of each of these four categories.

Table 6 Functions (Subcategories) of Tool Types

1. DERIVE/ALLOC.	2. DESIGN	3. ASSESS	4. MATURE
Setting requirements	System architecture	Inherent testability	Feedback analysis
Allocate requirements	Design rules and practices	Diagnostic effectiveness	
Optimize mix	Diagnostic authoring	Maintainability demonstration	
Risk analysis			

60.4.2 Tool descriptions. (This section will contain a list of tools related to the ID process described in this standard. For now, a diagnostic-related tool listing can be found in the Draft Final Technical Report for GIMADS Task 17, 8 June 1990. Contact ASD/AEGB, Wright-Patterson AFB, OH 45433 for information.)

APPENDIX E

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70. TECHNICAL DATABASE

70.1 SCOPE. The information structure described in this appendix may be used when performing the requirements derivation and allocation process in Appendix B. Potential types of data and information elements that may be used in the design, development, testing, and support of a weapon system are also provided. These information elements may be used in all of the development phases of a weapon system.

70.1.1 PURPOSE. This appendix helps provide a well defined, structured information process to ensure that needed data and generated data are available when necessary. This appendix also provides guidance on the types of data and information elements a design team may need to determine and implement diagnostics in a design and which types of data may be needed by personnel in the field to support a weapon system. Information that impacts or pertains to the acquisition and design of a weapon system should be considered for inclusion in the data sharing plan (See Appendix A, 3.1.2.3.1, 3.1.3.3.1, 3.1.4.3.1, 3.2.3.1).

70.1.2 APPLICATION. To implement the Appendix B process, data is needed and generated. This data must move through an information structure that supports the requirements derivation and allocation process described in Appendix B. This structure should also provide a good foundation for developing information structures in support of other related processes. The data requirements should be tailored early to the specific program to prevent loss of needed data and the collection of unwanted data.

Caution should be used when designing a database to implement an information structure. Proper handling of proprietary and classified data is essential but should be accomplished so as to not inhibit access to needed data by authorized users. Some data may be proprietary and need to have access limited to those working a specific program or employed by particular contractors. Other data may be classified and have access limited to cleared personnel. Protection of classified data is mandated by several existing federal, DoD, and USAF regulations and documents, such as DoD 5220.22-M and MIL-HBK-59. Any conflict between this standard and documents covering security will be resolved in favor of security documents. Particular attention must be paid when unrestricted information is used in conjunction with proprietary or classified information. If this information is needed for diagnostics, procedures must be developed and followed to ensure against unauthorized disclosure or compromise during diagnostic design, test, production, or use in the field.

Electronic data handling systems planned to contain classified data must be evaluated for TEMPEST countermeasures. If it is determined TEMPEST countermeasures are needed, the contractor and the DoD agency involved in the contract should ensure that security guidelines are followed. These guidelines may be found in such documents as DoD Directive 5200.19, Control of Compromising Emanations, 23 February 1990; Classified Confidential and the National Telecommunications and Information Systems Security Instruction (NTISSI), AFR 56-16; and National Communications Security Instruction (NACSI) 5004 (Classified Secret), January, 1984.

70.2 APPLICABLE DOCUMENTS.

(NOTE: These documents are not to be applied contractually except to the extent that specific portions are cited in the requirement statements or verification statements.)

70.2.1 Government documents

70.2.1.1 Specifications, standards, and handbooks

AFGS-87256	Integrated Diagnostics
MIL-HDBK-59	DoD Computer-Aided Acquisition and Logistics Support (CALS) Program Implementation Guide

70.2.1.2 Other Government documents, drawings, and publications.

AFR 56-16	Control of Compromising Emanations (TEMPEST)
DoDD 5200.19	Control of Compromising Emanations
National Communications Security Instruction 5004 (Secret)	

70.3 INFORMATION STRUCTURE. Information must be accessible and processed to accurately perform the requirements derivation and allocation process presented in Appendix B. Information will also be produced or generated during this process. Figure 24 illustrates the basic approach to an information structure. This information structure is based on the fact that each activity in the requirements derivation and allocation process will have information fed to it (input) and, as a result of performing the activity, will produce certain types of information (output).

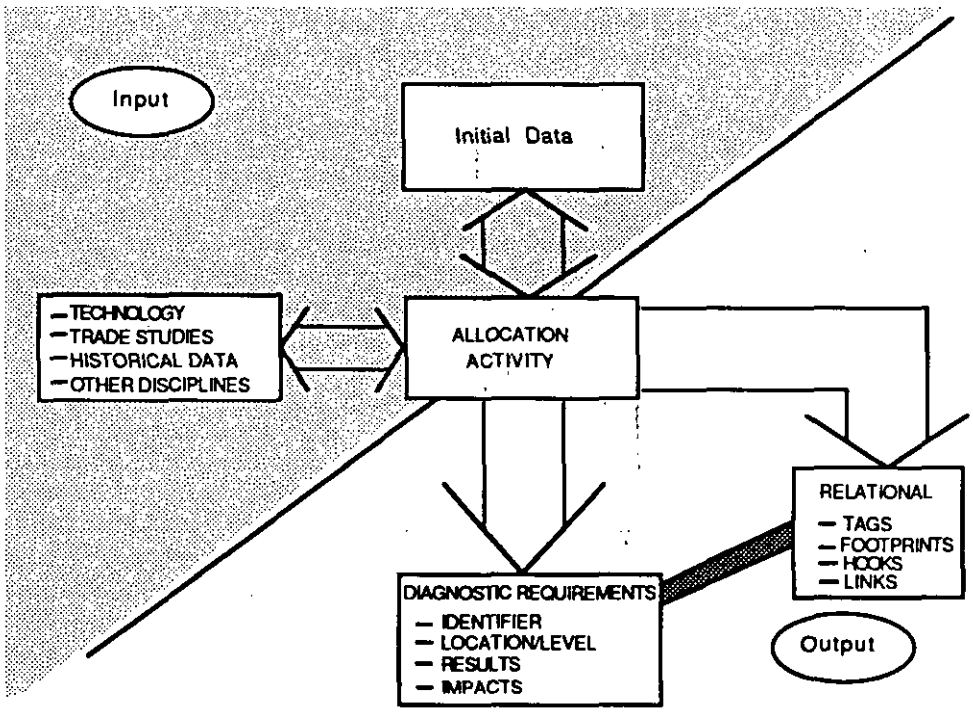

Figure 24 Information Structure

Input information can generally be broken down into two categories. The first (initial data) is information that is provided or already available, such as a Statement of Operational Need (SON). As this information is assimilated, analyzed, and studied, it may be determined that additional information is needed to perform the allocation activity. This is the second type of input information, information which must be determined, researched, and acquired to help perform the activity. The results of trade studies, operational models, and technical libraries may provide this additional information. This information is meshed together and analyzed as the allocation activity is performed, and output information (conclusions, decisions, results) emerge. Output information is generally of two types: information that is the product of the process, such as diagnostic needs or diagnostic requirements; and information that links the product to the inputs, assumptions, models, tools, etc., that led to the specific outcome of the process step, which may be considered by-product information. Product information is the reason the activity was performed. By-product information facilitates in process verification, auditing of the requirement development process, and future iterations of the activity.

By-product information is a critical aspect of the information structure. As input information is used to perform a process, by-product information may be generated as an audit trail to tie the inputs to the specific outcome being produced. The exact method of linking supporting information to outputs may vary. Supporting information may be attached to the output or may be linked by simply providing a reference to its source. If the information is accessable in a shared database, a reference and a link tying that information to the requirement may be sufficient. However, if the information was retrieved from a separate source, such as a text book, including it in the shared database in some format should be considered for ease of access but not be required as long as the information remains accessible elsewhere. A record of all information used and its location should be maintained so any user of the process can readily locate and retrieve the information used in formulating or supporting each outcome. Each output product should have its supporting input information tied or linked to it by appropriate by-product information (tags, footprints, hooks, or some other form of relational tie). In a system engineering environment, all types of input and output information would become part of a shared database. Additionally, certain types of information may be generated or modified and should become part of the shared database with the same linkages. Linkages should be applied to all information used, whether it is included in a shared database or not. This information (as taken from the tables of suggested data in this appendix) may include diagnostic criticality, diagnostic event, equipment required to diagnose, and location or level of diagnostic action. When the allocation step is complete, a record of the product, referencing the information used to generate that product and the rationale for the product, should be documented. As stated before, some type of relational structure tying the product to its supporting information should be a part of that record.

Since input information may be used to produce more than one output, by-product links can reduce duplication by referring to a single information source. Additionally, having only one source eliminates the problems of updating many versions or using an outdated version. The goal should be to create the data only once and to make it available to many users. However, this should not preclude a copy of the source data staying with an output document if this is considered more expedient or effective.

70.3.1 TRANSLATION. The allocation process begins (Figure 25) when a document establishing operational needs is presented to the system engineer, chief engineer, etc. This document may be in the form of a SON and/or other documents such as those listed in 20.2.1.1, 20.1.1.3, or 20.1.1.4. These operational needs must then be translated into diagnostic needs, collated into diagnostic requirements, and allocated to the appropriate diagnostic element and design level for implementation.

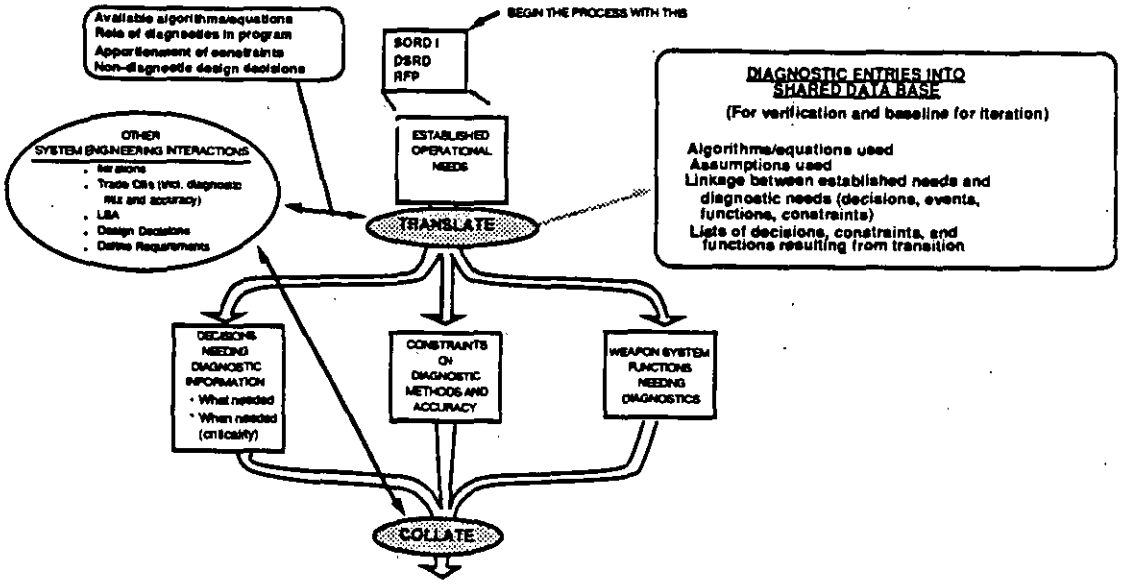

Figure 25 Translation Step

However, sufficient information must be available to translate those operational requirements into diagnostic needs. Some of the types of information needed may include available algorithms/equations, the role of diagnostics in the program, apportionment of constraints, and non-diagnostic design decisions. As information needed to perform this task is determined, that information must be located or generated. Some of the specific types of data listed and discussed later in this appendix that may be needed include function, diagnostic cost (both direct and indirect), diagnostic criticality, diagnostic event, and designer. This information may come from sources as varied as an automated database, CAD/CAM files, or an individuals personal file in their desk drawer (corporate memory). In other words, information may not always be formally documented. A data structure is needed to eliminate the loss of valuable information kept in informal "files," loss of the "corporate memory" by the transfer of certain individuals, or lack of an audit trail to the information used to make a certain decision. Whatever method the designer uses, it should give the exact source of the information used and how it can be found and accessed.

The output products of the translation step are diagnostic needs, decisions needing diagnostic information, system functions that must be reported for each event, and constraints on diagnostics.

70.3.2 COLLATION. The products of the translation step become the initial data for the collation process, as shown in Figure 26. If clarification is needed or the designer wishes to verify a certain bit of information, the designer may use the link or tag to locate the source/supporting data used. Decisions and information from higher design levels or prior iterations of the process may also be part of the inputs. The designer may also need and use additional information to perform the collation step (such as LSA, trade studies, new technologies, cooperative analyses, support resources availability, and other studies). When the output requirements are determined, they should be documented and recorded in the shared database. The designers should again link the input information, including all models used and any design tool used in each of the steps and additional supporting data used in the collation step, to the output information to continue the audit trail of the design decision process. This

information should include the rationale for writing specific requirements, rationale for assigning constraints, and other pertinent data.

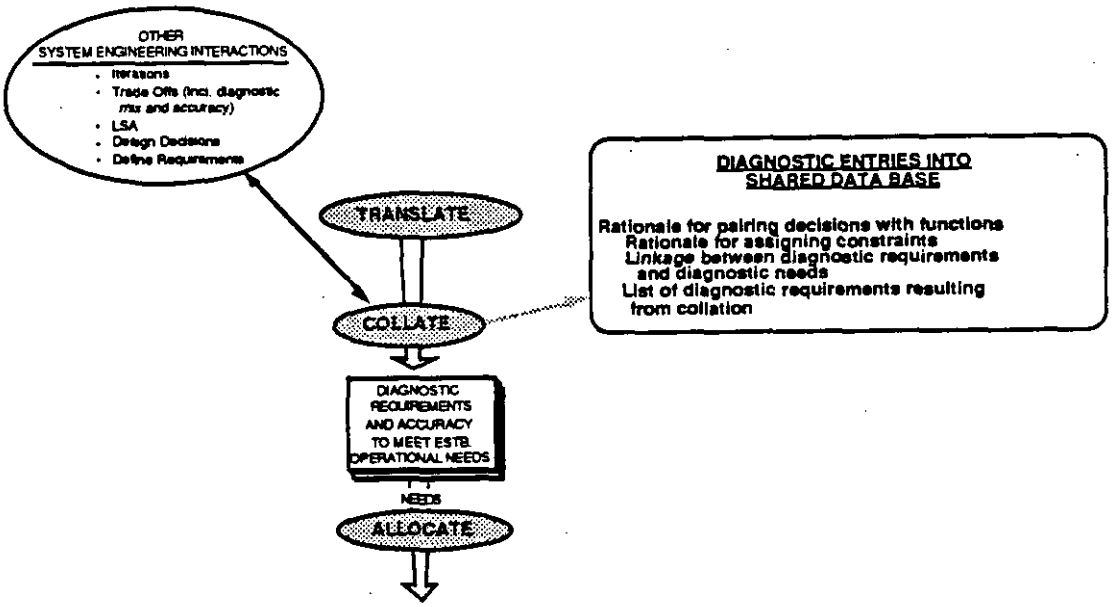

Figure 26 Collation Step

Once the diagnostic requirement has been derived, it must be properly documented so that diagnostics design can be accomplished and the appropriate diagnostic mix may be determined and implemented. The information that forms a requirement can be divided into two basic categories (Figure 27). The first category, information that may be regarded as the actual requirement, will be referred to as primary information. The second category (secondary information) is information linked to the primary information to provide an audit trail of the information and decisions that led to the requirement.

APPENDIX F

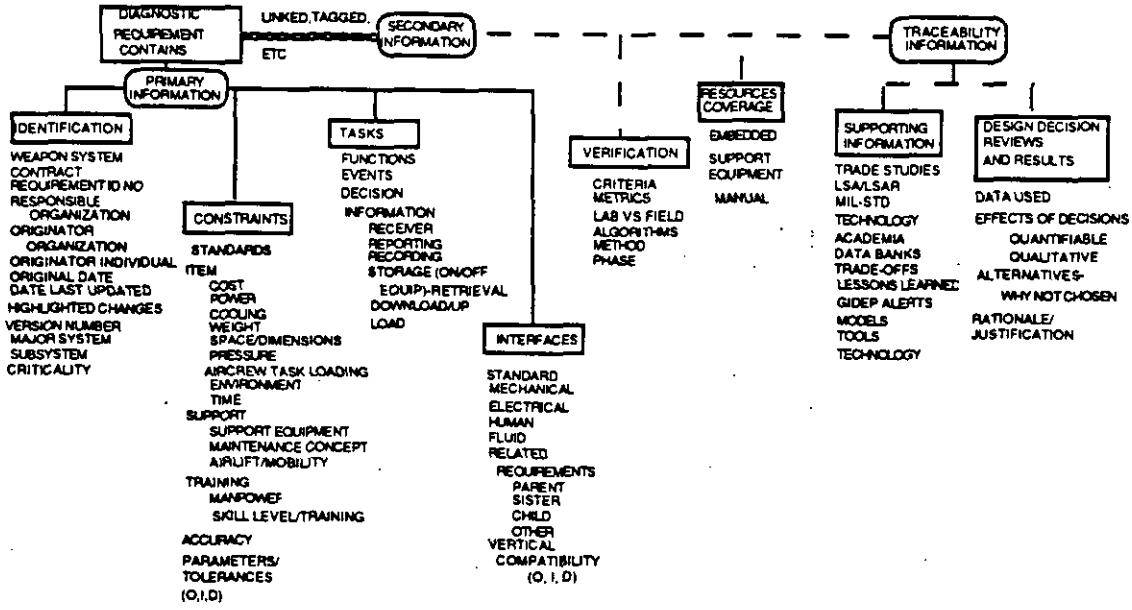

Figure 27 Basic Structure

Primary information is subdivided into four branches. These branches are identification, tasks, contraints, and interfaces. Identification is such information as the contract number and/or item the requirement applies to, responsible organizations and individuals, and update information, such as date of last change and recounting or highlighting of changes. The next branch (tasks) may be considered the main part of the requirement. It is in this branch that the designer will find the information that will directly influence and impact how the design is to be accomplished. The parts of this branch will include, for example, the function that will be diagnosed, the decision that requires the diagnostic information, and the event during which the decision is expected to be made. Other branches include constraints and interfaces. Constraints are information that provide limits for the design. Such areas as cost, schedule, weight, power, and allowable support equipment are constraints. Interfaces will list the relationships of the requirement with other areas and how the requirement will interact with other systems including connectors, power and information transmission means, how the system will interface with human operators, and relationships between levels of test and levels of maintenance.

The structure of a single requirement's primary information is illustrated in Figure 28. Starting with the identification information, certain information must be provided to give each requirement a unique identity. This information should include the design level at which this requirement applies, some type of unique identification code or number, who originated the requirement and when it was originated, and who is currently responsible for it as well as some means of identifying the most current version. The function to be covered should be identified and its criticality should be established. System and general constraints that must be met should be identified. The events in which diagnostic decisions are needed and the diagnostic decisions within each event should be identified. This may be done either by linking multiple requirements for each decision or by "layering" the events and decisions within the function requirement. Each decision may be subdivided into a recommended or estimated design mix (embedded, support, manual). Each element of the mix should identify applicable event specific constraints (such as time and accuracy parameters/tolerances), information needs (includes both needed by the designer about the design and diagnostic data that will be needed

by the function), information reporting/ generated (includes both generated by the designer about the design and diagnostic data that will be reported by the function), and interfaces that must be considered (including physical, electrical/signal, human, etc.). Since not all of the areas identified will always be needed or available, the suggested structure should be used as a guideline for tailoring specific requirement structures.

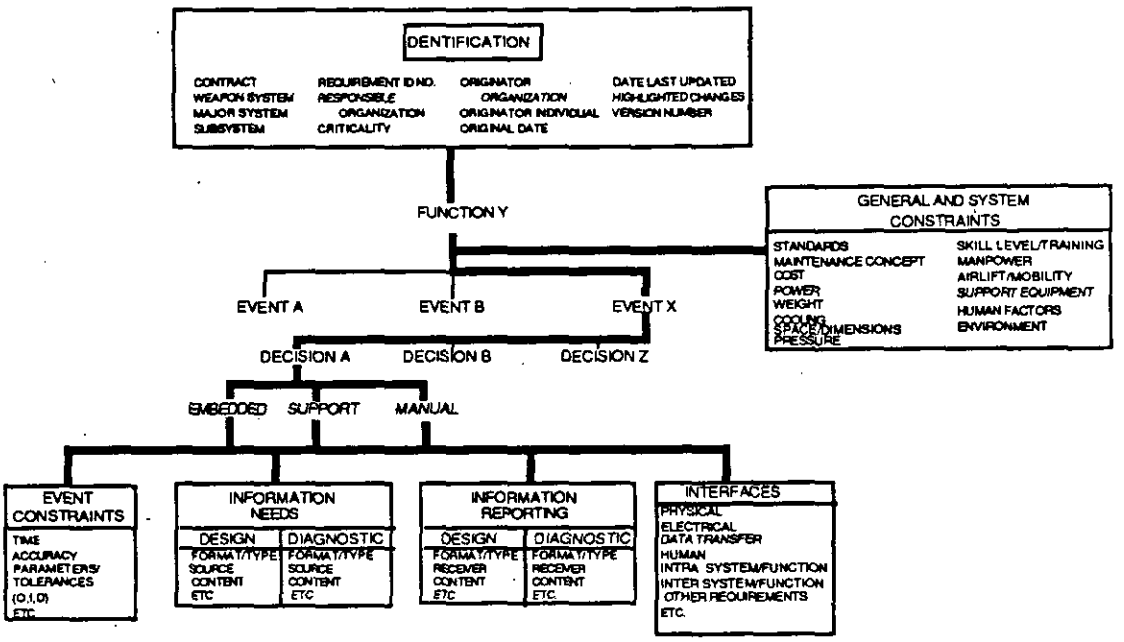

Figure 28 Requirement Structure

The other category (secondary information), illustrated in Figure 27, is information that is not a direct part of a requirement but which supports, expands, clarifies, or describes the formulation of the requirement. This is information that is linked to provide the designer an audit trail on design decisions, models, tools, data, etc., leading to the requirement. This trail provides the capability to determine impacts of "upstream" changes or modifications during the allocation process and, if necessary, determine tradeoffs later in the process that may be required to meet the diagnostic needs. Figure 29 illustrates one way of presenting this data by separating it into several branches, including design decision documentation (data used, effects of decision, rationale, alternatives), supporting information (previous trade studies, LSA/LSAR, technology, models used, tools used), verification (criteia, metrics, lab vs. field, algorithims, and method), and resources available (embedded, support equipment, manual).

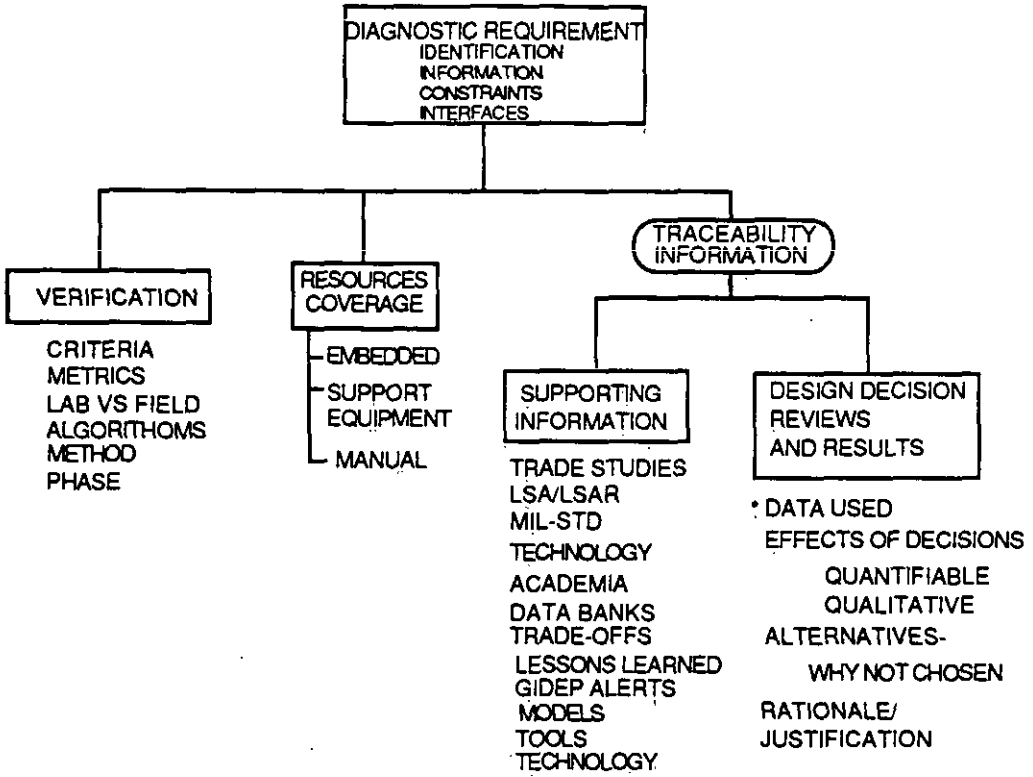

Figure 29 Support Elements

Although each requirement that is collated should have a separate and unique identity, they may be overlapping and multiple layers deep. For example, a diagnostic requirement may be written against a specific function within a system. That function may have several diagnostic events related to it. Each event may have one or more constraints, and these may be shared or interrelated with the constraints of the other events within the same functions. The requirement will have to address several layers simultaneously, including maintenance level (O-level, I-level, D-level), relationships between system level (major system, segment, element), criticality (safety, mission, maintenance), method of diagnostics (embedded, support equipment, and manual), and impact on other resources, such as manpower, training, tech data, and support equipment for each level.

70.3.3 ALLOCATE. Once the diagnostic requirements are determined and documented, they become input data for the allocation step (Figure 30). In deciding where and how to allocate requirements, additional information may be needed. This information may be new, or it may be data already generated or collected during the translation or collation steps. Additional information needed may include trade studies, verification methods available, operational and life cycle models used, CAD/CAM or other tools used, schedules, costs, and milestones.

As a result of the allocation steps, functional requirements for lower design levels and/or physical implementations for embedded, support equipment, or manual systems will be generated. The designer should feed into the shared database the methodologies/tools/models and assumptions used, options explored, linkage to parent or initial requirements, linkages to related children or lower level requirements, and lists of physical and functional requirements resulting from the allocation decisions. The process would end with a set of physical

diagnostic requirements for decisions/events addressed during the development phase being considered and a set of functional diagnostic requirements for decisions/events to be addressed in later phases or for functions applicable to design levels not yet addressed.

The basic three-step process should be iterated as a program progresses, and the data structure should be updated as necessary. The resulting diagnostic requirements become established needs for the translation step at the next design level. This process continues until it is determined that the requirement is beyond the scope of the next lower level and, thus, must be resolved at the current level.

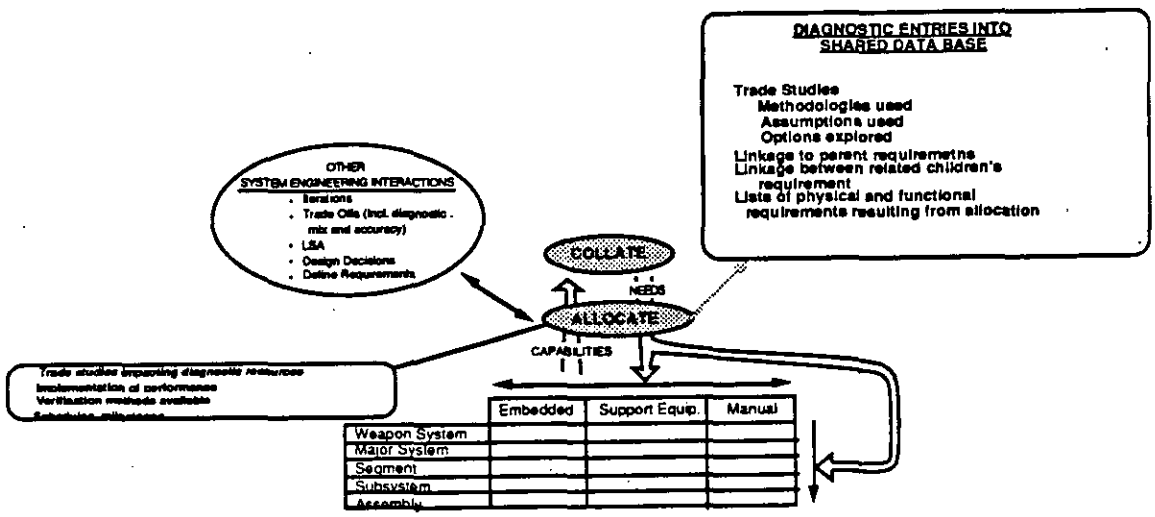

Figure 30 Allocation Step

Figure 31 illustrates how the three steps combine to form a structured process and information flow. As each requirement, or each design level (starting at the segment level), is completed and as the allocation to the next level takes place, the process begins again at that level with the translation step. Thus, the basic structure may be used and repeated several times as the process is conducted for each successive design level and acquistion phase, as is described in Appendix B.

APPENDIX F

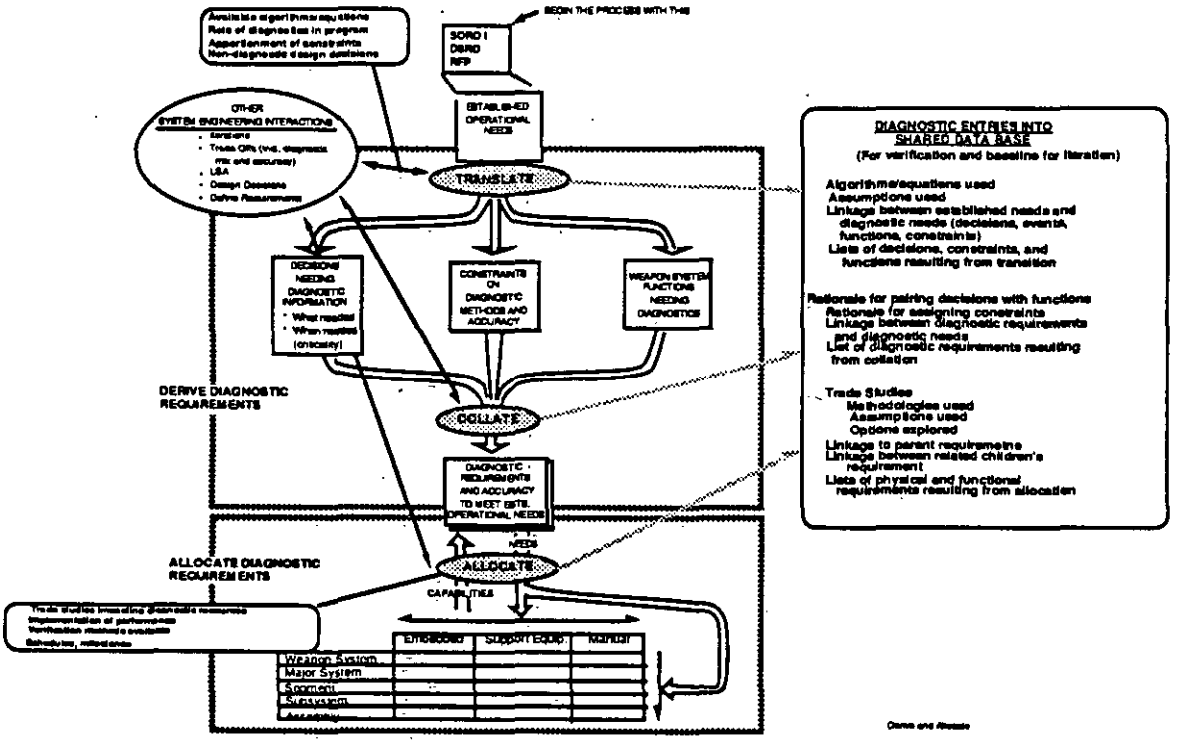

Figure 31 Allocation Process

With a proper data structure, any user of the system should be able to enter at any point, phase, or design level, regardless of how far the process has progressed and be able to trace the requirement history, decision documentation, and supporting data back to the original operational need. This data structure should provide a means for tracking, selecting, or verifying data needed or used during the translation, collation, and allocation of diagnostic requirements.

70.4 INFORMATION ELEMENTS. The types of data required to perform the steps in the allocation process may vary depending on several factors, including the development phase, the design level, and the step in the allocation process currently in work. Data requirements must be tailored to the task being accomplished in order to ensure accurate decisions and requirements. Data required for one step or system may be nebulous for another. The following tables present a range of suggested data and information elements that may be used in the acquisition and support of a weapon system. These tables do not, nor do they intend to, list every possible type of element that may be required in each of these categories. Conversely, not every data element will be used by every weapon system or user, or in every database, whether it be design or performance related. Acquisition authorities, contractors, and the user may use this appendix and the other appendices of this standard as a starting point to tailor their databases to their specific needs and requirements. Contractors may use this as a guide or baseline when developing their shared database.

The data types presented here fall into one or more of the following categories.

Engineering Data
Performance Data
Historical

APPENDIX F

Verification
Feedback

Engineering data, per MIL-HDBK-59, contains "authoritative engineering definition or guidance on material, items, equipment system practices, methods, and processes relating to the design, manufacture, acquisition, test, inspection or maintenance of items or services. Engineering data includes the following: drawings, associated lists, contractor or vendor specifications, standards, documents referenced on drawing lists, revision authorization documents, engineering change orders, government or industry associated specifications and standards, and other related documents".

Historical type data is data on similar or other specified systems that may be used as a baseline during the design process. Verification data is collected during the development and test phases of the design to assist in determining if the requirements and the predicted design performance are being met. Feedback (field) data is collected after the design has gone into production and is in use. This data is normally collected by the user and may be used to monitor the performance of the design in the operational environment or assist in the actual diagnosing of faults. This data may perform a dual role as it becomes historical data for the next generation of design. During the early stages of design, performance information from previous weapon systems may be used by designers as a baseline comparison for new systems. Data generated during the test phases (such as Initial Operational Test and Evaluation or Development Operational Test and Evaluation) may also be used to determine the effectiveness of the design and whether it met the design requirements. During later stages, verification data and field data from operational units may be used to determine the actual performance of the design and evaluate the adequacy of the data being collected (See Appendix A, 3.1.3.5, 3.1.4.4.7, 3.2.3). This data may be collected on performance or management oriented data systems, such as from the Air Force Core Automated Maintenance System (CAMS), Comprehensive Engine Management System (CEMS), Turbine Engine Management System (TEMS), Depot Maintenance Management System (DMMIS), Tactical Interim CAMS and REMIS Reporting System (TICARRS); from individual aircraft records (AFTO 781 series) or maintenance data collection (AFTO 349) records; or from shared databases generated and maintained by the individual contractor.

The listed data has not been identified by category due to the confusion that may arise from its varied use and combinations, dependent on the location in the development process.

The data and information elements listed in the tables is a result of information gathered in three surveys conducted by GIMADS of various contractors, acquisition agencies, and users and from interviews with design groups and field personnel. The data and information elements are presented in the development phase in which it may be a factor. Thus, a data and information element may be listed multiple times. For the purpose of this appendix the development phases have been categorized as follows.

Concept Exploration (C/E),
Demonstration/Validation (Dem/Val),
Full Scale Development (FSD)
Production/Deployment

The tables have been organized into five columns.

First column. Types of data elements that show the kind of information that is needed but are not intended to be the data elements themselves. These elements are not inclusive of all possible elements and may be a general term for a larger grouping of lower level elements.

Second column. Levels of design or maintenance that may need that type of data in the performance of their tasks. This listing shows all possible organizations that may need this data throughout the life cycle of the design without regard to the development phase being depicted.

Third column. Design organizations or maintenance levels that may generate a particular data element. Multiple organizations may be a source for or involved in generating the data. Future editions of this appendix will be refined to include only those organizations that will be active in the phase being shown.

Fourth column. Information systems with broad access capability (i.e., government data systems) that may be used as a source for that type of data. Individual contractor databases have not been listed. In some cases, the data may not be currently available in any form of organized database. Thus, procedures should be developed to ensure that this data is collected, stored, and made available to those who need it.

Fifth column. Integrated Diagnostics MIL-STD-1814 paragraph numbers/diagnostic Roadmap activity numbers where a specific data element may be used. By using these numbers for the applicable data elements, the reader can identify phases of the development process that may use these elements. These listings provide all activities in which this element is used and not just to those applicable in the development phase being shown. This was done to illustrate the possible scope of use of the data element being shown.

It should be noted that, in many cases, the data are described at a high level or generic name due to the proliferation of possible names or items under that level (example: studies and statistics under support data). Also, the reader should be aware that some data elements come under different names, although they may mean the same type of data (example: aircraft serial number vs. aircraft tail number vs. Bureau Number). In these cases, it was attempted to group under a common name, although it was recognized that multiple names/identifiers exists. In some cases, the element will have a dual use, depending on the phase in which it is called out. For example, during the early design phases, the designer will determine and identify the specific LRU/LRMs that will belong to the individual ambiguity groups based on the decisions as to the level of diagnostics. This information must be available to several, if not all, of the disciplines in the design process. In the support or field performance of a weapon system, the technician must know or have access to the identity of the specific components that make up an ambiguity group identified during the diagnostic process in order to correctly make repairs.

CONCEPT EXPLORATION PHASE

PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
AMBIGUITY GROUP	TPS DESIGNERS, D-ENG, O-LEVEL, I-LEVEL, D-LEVEL, SYSTEMS DESIGNERS	TPS DESIGNERS, MAINTAINABILITY O-LEVEL, I-LEVEL, D-LEVEL, D-ENG SYSTEMS DESIGNER, GOVERNMENT AUTH.	LSAR MIL-STD-1388B, CITS, TRD MIL-STD-1519	3.1.4.4, 3.1.3.5, 3.1.4.5, 3.2.3.3,
CREW SIZE	MX CONT, ANALYSIS, LSA, SYSTEM/SUBSYSTEM DESIGNERS, TPS DEVELOPERS	SYSTEM/SUBSYSTEM DESIGNERS, TPS DEVELOPERS	CAMS, 3M, 66-1 SEDS, LSAR, TICARRS, MODAS, TEMS, DO56, CEMS, DMMIS	3.1.3.4.1, 3.1.4.4.1
DIAGNOSTIC COST-DIRECT	ACQUISITION AUTHORITY CONTRACTOR DECISION AUTHORITY			3.1.3.4
DIAGNOSTIC COST-INDIRECT	AFLC, LCC, ASD, CONTRACTOR FIELD SUPPORT	O-LEVEL, I-LEVEL, D-LEVEL, DESIGNERS, ENGINEERS	CALCULATED FROM RAW DATA	3.1.3.4
DIAGNOSTIC CRITICALITY	DESIGNERS/ENGINEERS, ACQUISITION AUTHORITY	DESIGNERS/ ENGINEERS		3.1.3.4, 3.1.4.4.1, 3.1.4.7.1, 3.1.4.7
DIAGNOSTIC DESCRIPTION	ACQUISITION, AFLC CONTRACTORS, USER,	DESIGNERS/ ENGINEERS	781s, 349	3.1.3.4

Table 7 Data Matrices

CONCEPT EXPLORATION PHASE

PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
DIAGNOSTIC EVENT	DESIGNERS/ENGINEERS	ACQUISITION AUTHORITY, CONTRACTOR DECISION AUTHORITY		3.1.4.4, 3.1.4.7, 3.1.3.5, 3.1.4.5, 3.2.3.3
DIAGNOSTIC METHOD	O-LEVEL, ANALYSIS, AFLC SUPPORT, I-LEVEL, LRU/LRM DESIGNER, D-LEVEL, D-ENG, DESIGNER, LSA/LCC, TPS DEVELOPER	D-ENG, CONTRACTOR SUPPORT	MMICS, CAMS, SEDS, TICARRS	3.1.2.4.1, 3.1.3.4.1, 3.1.4.4, 3.1.7, 3.1.3.5,3.2.3.3
DIAGNOSTIC OUTCOME AND CODE	AFOTEC, AFLC SUPPORT I-LEVEL, D-LEVEL, ANALYSIS, O-LEVEL, CONTRACTOR SUPPORT, D-ENG, MX CONT, DESIGNER TE, TPS DESIGNER	AFOTEC, I-LEVEL, CONTRACTOR SUPPORT		3.1.2.4, 3.1.3.5, 3.1.4.4
DIAGNOSTIC TIME	AFOTEC, DESIGNER MX CONT, MAJCOM, D-LEVEL, O-LEVEL, I-LEVEL,	AFOTEC, O-LEVEL, I-LEVEL, D-LEVEL	MMICS, SEDS, CAMS, TICARRS,	3.1.2.4 3.1.4.4, 3.1.3.5, 3.2.3.3, 3.1.4.5
EQUIPMENT REQUIRED USED TO DIAGNOSE LOCATION OR LEVEL OF DIAGNOSTIC ACTION	O-LEVEL, I-LEVEL, D-LEVEL, MX CONTROL, CONTRACTOR FIELD SUPPORT, ANALYSIS	SYSTEM INTEGRATOR, O-LEVEL, I-LEVEL, D-LEVEL	LSAR, AFTOMS	3.1.3.1.2, 3.1.3.4, 3.1.4.11 3.1.3.4
RECONFIGURATION HISTORY	DESIGNER, O-LEVEL, ATE DEVELOPER, I-LEVEL, D-LEVEL, D-ENG	O-LEVEL, I-LEVEL, D-LEVEL		3.1.3.5, 3.1.4.5, 3.2.3.3, 3.1.3.4,3.1.4.4.

Table 8 Data Matrices

DEMONSTRATION/VALIDATION PHASE

PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
AMBIGUITY GROUP	TPS DESIGNERS, D-ENG, SYSTEM DESIGNERS, O-LEVEL, I-LEVEL, D-LEVEL	TPS DESIGNERS, O-LEVEL, MAINTAINABILITY, D-ENG, SYSTEMS DESIGNER, D-LEVEL, GOVERNMENT AUTHORITY, I-LEVEL	LSAR(MIL-STD-1388B), CITS, TRD (MIL-STD-1519)	3.1.4.4, 3.1.3.5, 3.1.4.5, 3.2.3.3
CREW SIZE	MX CONT, ANALYSIS, LSA, SYSTEM/SUBSYSTEM DESIGNERS, TPS DEVELOPERS	SYSTEM/SUBSYSTEM DESIGNERS, TPS DEVELOPERS	66-1, DMMIS, SEDS, LSAR, CAMS, 3M, DO56 TICARRS, TEMS, MODAS, CEMS	3.1.3.4, 3.1.4.4
DIAGNOSTIC CODE - OPERATIONS/ MAINTENANCE	AFOTEC, ANALYSIS, MX CONT, CONTRACTOR FIELD SUPPORT, O-LEVEL, I-LEVEL, D-LEVEL	AFOTEC, DEBRIEF, O-LEVEL, I-LEVEL, D-LEVEL	SEDS (AFOTEC)	3.1.3.4., 3.1.4.4, 3.1.4.7, 3.1.4.5, 3.2.3.3
DIAGNOSTIC COST-DIRECT	ACQUISITION AUTHORITY, CONTRACTOR DECISION AUTHORITY			3.1.3.4
DIAGNOSTIC COST-INDIRECT	AFLC, ASD, CONTRACTOR FIELD SUPPORT, LCC	O-LEVEL, I-LEVEL, D-LEVEL, DESIGNERS/ENGINEERS	CALCULATED FROM RAW DATA	3.1.3.4
DIAGNOSTIC CRITICALITY	DESIGNERS/ENGINEERS, ACQUISITION AUTHORITY	DESIGNERS/ENGINEERS		3.1.3.4, 3.1.4.4, 3.1.4.7.1, 3.1.4.7
DIAGNOSTIC DESCRIPTION	ACQUISITION, CONTRACTORS, USER, AFLC	DESIGNERS/ENGINEERS	781s, 349s	3.1.3.4

Table 9 Data Matrices

DEMONSTRATION/VALIDATION PHASE

PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
DIAGNOSTIC EVENT	DESIGNERS/ENGINEERS	ACQUISITION AUTHORITY, CONTRACTOR DECISION AUTHORITY		3.1.4.4, 3.1.4.7, 3.1.3.5, 3.1.4.5, 3.2.3.3, 3.1.2.4, 3.1.3.4
DIAGNOSTIC MANHOURS	AFOTEC, MX CONT, O-LEVEL, I-LEVEL, D-LEVEL, MAJCOM, DESIGNER	AFOTEC, O-LEVEL, I-LEVEL, D-LEVEL	MMICS, CAMS, TICARRS, SEDS, DO56	3.1.4.4, 3.1.4.7, 3.1.3.5, 3.1.4.5, 3.2.3.3, 3.1.2.4, 3.1.3.4
DIAGNOSTIC METHOD	O-LEVEL, ANALYSIS, I-LEVEL, LRU/LRM DESIGNER, LSA/LCC, D-LEVEL, D-ENG, DESIGNER, TPS DEVELOPER, AFLC SUPPORT	D-ENG, CONTRACTOR SUPPORT	MMICS, CAMS, TICARRS, SEDS	3.1.2.4, 3.1.3.4, 3.2.3.3, 3.1.4.4, 3.1.4.7, 3.1.3.5
DIAGNOSTIC OUTCOME AND CODE	AFLC SUPPORT ANALYSIS, I-LEVEL, AFOTEC, D-LEVEL, O-LEVEL, CONTRACTOR SUPPORT, D-ENG, MX CONT, TPS DESIGNER, TEST ENGINEER, DESIGNER	AFOTEC, CONTACTOR SUPPORT, I-LEVEL		3.1.3.5, 3.1.4.4
DIAGNOSTIC TIME	AFOTEC, MX CONT, O-LEVEL, I-LEVEL, D-LEVEL, MAJCOM, DESIGNER	AFOTEC, O-LEVEL, I-LEVEL, D-LEVEL	MMICS, CAMS, TICARRS, SEDS	3.1.2.4
EQUIPMENT REQUIRED/ USED TO DIAGNOSE FAULT CODE	O-LEVEL, I-LEVEL, D-LEVEL, DEBRIEF, D-ENG	SYSTEM INTEGRATOR, DEBRIEF, O-LEVEL, D-LEVEL	LSAR, AFTOMS, 66-1, CAMS, TICARRS, 3M, DMMIS	3.1.3.4.1, 3.1.3.4, 3.1.4.4 3.1.4.7, 3.1.4.11

Table 10 Data Matrices

DEMONSTRATION/VALIDATION PHASE

PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
FAULT DESCRIPTION	AFOTEC, O-LEVEL, I-LEVEL, CONTRACTOR FIELD SUPPORT, D-LEVEL, MX CONT, DEBRIEF, AFLC SUPPORT ANALYSIS	AFOTEC, DEBRIEF, O-LEVEL	MMICS, CAMS, TEST VECTOR RESULTS, SEDS, TICARRS, FMEA, BIT RESULTS, CITS, TEMS, CEMS, SPECIFICATIONS	3.1.3.4, 3.1.4.4, 3.1.4.7, 3.2.3.3,
FLIGHT HOURS	DEBRIEF, ANALYSIS, CONTRACTOR FIELD SUPPORT	DEBRIEF	66-1, CAMS, 3M, TICARRS, CITS, MODAS	3.1.3.5, 3.1.4.5, 3.2.3.3, 3.3.1, 3.1.2.4
JOAP RESULTS	D-LEVEL, MX CONT, O-LEVEL, I-LEVEL	I-LEVEL, MX CONT	CEMS, TEMS	3.1.3.5, 3.1.4.5, 3.2.3.3
JOB CONTROL NUMBER	MX CONT, AFOTEC, DEBRIEF, CONTRACTOR FIELD SUPPORT, O-LEVEL, I-LEVEL, D-LEVEL, AFLC SUPPORT ANALYSIS, D-ENG, ANALYSIS	MX CONT, DEBRIEF, O-LEVEL, I-LEVEL, D-LEVEL, AFOTEC	CAMS, 66-1, MMICS, SEDS, TICARRS, 3M, DMMIS, MODAS	3.1.3.5, 3.1.4.5, 3.2.3.3
LOCATION OR LEVEL OF DIAGNOSTIC ACTION	MX CONT, CONTRACTOR FIELD SUPPORT, ANALYSIS	O-LEVEL, I-LEVEL, D-LEVEL		3.1.3.4, 3.1.4.4.1, 3.1.4.4.2, 3.1.3.5, 3.1.4.5, 3.2.3.3, 3.1.2.4
RECONFIGURATION HISTORY	DESIGNER, ATE DEVELOPER, D-ENG, O-LEVEL, I-LEVEL, D-LEVEL	O-LEVEL, I-LEVEL, D-LEVEL		3.1.3.5, 3.1.4.5, 3.2.3.3

Table 11 Data Matrices

DEMONSTRATION/VALIDATION PHASE
PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
REPEAT/RECUR	O-LEVEL, I-LEVEL, D-LEVEL, D-ENG, ANALYSIS	DEBRIEF, O-LEVEL, I-LEVEL, D-LEVEL, ANALYSIS	66-1, CEMS, CAMS, TEMS, TICARRS, MODAS, G033	3.1.3.5, 3.1.4.5, 3.2.3.3
RESULTS OF EXPERT SYSTEMS	O-LEVEL, I-LEVEL, D-LEVEL, CONTRACTOR FIELD SUPPORT, ANALYSIS	DEBRIEF, O-LEVEL, D-LEVEL	66-1, CAMS, TICARRS, DMMIS	3.1.3.5, 3.1.4.5, 3.2.3.3
TEST REQUIREMENT DOCUMENT (TRD)	D-LEVEL AND I-LEVEL DEVELOPERS, USER, FACTORY TEST DEVELOPERS, TPS DEVELOPERS	SYSTEM DESIGNERS, FACTORY TEST DEVELOPERS	CERTAIN COMMERCIAL PROGRAMS	3.1.4.4, 3.1.4.7.1, 3.1.4.7.2, 3.1.4.11

Table 12 Data Matrices

FULL SCALE DEVELOPMENT PHASE
PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
AMBIGUITY GROUP	TPS DESIGNERS, D-ENG, D-LEVEL, I-LEVEL, O-LEVEL, SYSTEM DESIGNERS	MAINTAINABILITY ENG, TPS DESIGNERS, O-LEVEL, SYSTEMS DESIGNER, I-LEVEL, D-LEVEL, D-ENG, GOVERNMENT AUTHORITY	LSAR(MIL-STD -1388B), CITS, TRD (MIL-STD-1519)	3.1.4.4, 3.1.3.5, 3.1.4.5, 3.2.3.3,
BIT/ST FUNCTION DESCRIPTION	SYSTEM INTEGRATOR, END ITEM USER, TPS DEVELOPER	SUBSYSTEM DESIGNER, DESIGNER		3.1.4.4, 3.1.4.5, 3.1.4.7.1, 3.1.4.7.2, 3.1.4.11
COMPUTER PROGRAM IDENTIFICATION NUMBER (CPIN)	D-LEVEL	SYSTEM INTEGRATOR, TPS DESIGNERS	CAMS, TICARRS, AFTOMS, DMMIS	3.1.4.4, 3.1.4.7, 3.1.3.5, 3.2.3.3
CONNECTOR NUMBER/ID				3.1.3.5, 3.1.4.5, 3.2.3.3
CREW SIZE	MX CONT, ANALYSIS, LSA, SYSTEM/SUBSYSTEM DESIGNERS, TPS DEVELOPERS	SYSTEM/SUBSYSTEM , DESIGNERS, TPS DEVELOPERS	66-1, DMMIS, SEDS, LSAR, CAMS, 3M, TICARRS, MODAS, DO56, TEMS, CEMS	3.1.3.4, 3.1.4.4
DATE OF DIAGNOSTIC ACTION	CONTRACTOR FIELD SUPPORT, AFLC, ANALYSIS	O-LEVEL, D-LEVEL, I-LEVEL	66-1, D056, MMICS, REMIS, TICARRS, CAMS	3.1.3.4, 3.1.3.5, 3.1.4.5, 3.2.3.3
DIAGNOSTIC ACCURACY	AFOTEC, ANALYSIS, MAJCOM, ASD, AFSC, D-ENG, LSA/LCC LRU DESIGNER,AGE/TEST EQUIPMENT DESIGNER, TRAINING EQUIPMENT DESIGNER	AFOTEC, D-LEVEL, I-LEVEL, O-LEVEL	TO BE CALCULATED FROM RAW DATA	3.1.4.4, 3.1.4.7, 3.1.2.4, 3.1.3.4

Table 13 Data Matrices

FULL SCALE DEVELOPMENT PHASE
PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
			DATA COLLECTED IN FIELD OR ESTIMATED BY DESIGN	
DIAGNOSTIC CODE - OPERATIONS/ MAINTENANCE	AFOTEC, ANALYSIS, MX CONT, CONTRACTOR FIELD SUPPORT, O-LEVEL, I-LEVEL, D-LEVEL	AFOTEC, D-LEVEL, I-LEVEL, DEBRIEF, O-LEVEL	SEDS (AFOTEC)	3.1.3.4, 3.2.3.3
DIAGNOSTIC COST-DIRECT	ACQUISITION AUTHORITY, CONTRACTOR, DECISION AUTHORITY	LCC		3.1.3.4
DIAGNOSTIC COST-INDIRECT	AFLC, LCC, ASD, CONTRACTOR FIELD SUPPORT	O-LEVEL, D-LEVEL, I-LEVEL, DESIGNERS/ENGINEERS	CALCULATED FROM RAW DATA	3.1.3.4
DIAGNOSTIC CRITICALITY	DESIGNERS/ENGINEERS ACQUISITION AUTHORITY	DESIGNERS/ENGINEER		3.1.3.4, 3.1.4.4, 3.1.4.7, 3.1.4.4.1, 3.1.4.7.1, 3.1.4.7
DIAGNOSTIC DESCRIPTION	ACQUISITION, CONTRACTORS, USER, AFLC	DESIGNERS/ ENGINEERS	781s, 349	
DIAGNOSTIC EVENT	DESIGNERS/ENGINEERS, DECISION AUTHORITY	ACQUISITION AUTHORITY, CONTRACTOR		3.1.4.4, 3.1.4.7, 3.1.3.5, 3.1.4.5, 3.2.3.3, 3.1.3.4, 3.1.2.4
DIAGNOSTIC MANHOURS	AFOTEC, DESIGNER, MAJCOM,	AFOTEC, D-LEVEL, I-LEVEL,	MMICS, DO56,	3.1.4.4, 3.1.4.7, 3.1.3.5, 3.1.4.5, 3.2.3.3, 3.1.2.4, 3.1.3.4

Table 14 Data Matrices

FULL SCALE DEVELOPMENT PHASE
PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
	MX CONT, D-LEVEL, I-LEVEL, O-LEVEL	O-LEVEL	CAMS, SEDS, TICARRS	
DIAGNOSTIC METHOD	O-LEVEL, ANALYSIS, I-LEVEL, LRU/LRM DESIGNER, D-LEVEL, LSA/LCC, TPS DEVELOPER, D-ENG, DESIGNER, AFLC SUPPORT	D-ENG, CONTRACTOR SUPPORT	MMICS, CAMS, SEDS, TICARRS	3.1.2.4, 3.1.3.4, 3.1.4.4, 3.1.4.5, 3.1.3.5, 3.2.3.3
DIAGNOSTIC OUTCOME AND CODE	AFOTEC, AFLC, DESIGNER, I-LEVEL, SUPPORT ANALYSIS, D-LEVEL, TE, TPS DESIGNER, O-LEVEL, MX CONT, D-ENG, CONTRACTOR SUPPORT	AFOTEC, I-LEVEL, CONTACTOR SUPPORT		3.1.3.5, 3.1.4.4
DIAGNOSTIC TIME	AFOTEC, DESIGNER, MAJCOM, MX CONT, D-LEVEL, I-LEVEL, O-LEVEL	AFOTEC, D-LEVEL, I-LEVEL, O-LEVEL	MMICS, SEDS, CAMS, TICARRS	3.1.2.4, 3.1.4.4, 3.1.3.5, 3.2.3.3
EQUIPMENT REQUIRED/USED TO DIAGNOSE	O-LEVEL, D-LEVEL, I-LEVEL	SYSTEM INTEGRATOR	LSAR, AFTOMS	3.1.3.4, 3.1.4.4, 3.1.4.7, 3.2.3.3, 3.1.4.11
EQUIPMENT IDENTIFIERS	I-LEVEL, D-LEVEL	D-LEVEL	66-1, TICARRS, SEDS, AFTOMS, CAMS, LSAR, DMMIS, 3M	3.1.3.5, 3.1.4.5, 3.2.3.3
FAULT CODE	DEBRIEF, D-ENG, D-LEVEL,	DEBRIEF, D-LEVEL, O-LEVEL	66-1, TICARRS	3.1.4.4, 3.1.4.5, 3.1.3.5, 3.2.3.3, 3.1.3.4

Table 15 Data Matrices

FULL SCALE DEVELOPMENT PHASE
PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
	O-LEVEL, I-LEVEL		CAMS, DMMIS, 3M, AFTOMS	
FAULT DESCRIPTION	AFOTEC, O-LEVEL, I-LEVEL CONTRACTOR FIELD SUPPORT, D-LEVEL, AFLC SUPPORT, MX CONT, DEBRIEF, DESIGNERS, ANALYSIS	AFOTEC, O-LEVEL, DEBRIEF	MMICS, CEMS, CAMS, CITS, SPECIFICATIONS, TICARRS, TEST VECTOR RESULT, BIT RESULTS, TEMS, FMEA, SEDS	3.1.3.5, 3.1.3.4, 3.2.3.3, 3.1.4.5
FLIGHT HOURS	DEBRIEF, ANALYSIS, CONTRACTOR FIELD SUPPORT	DEBRIEF	66-1, MODAS, CAMS, CITS, TICARRS, 3M	3.1.3.5, 3.1.4.5, 3.2.3.3, 3.3.1, 3.1.2.4.2
JOAP RESULTS	D-LEVEL, MX CONT, I-LEVEL, O-LEVEL	I-LEVEL,MX CONT	CEMS, TEMS	3.1.3.5, 3.1.4.5, 3.2.3.3
JOB CONTROL NUMBER	MX CONT, AFOTEC, D-LEVEL, CONTRACTOR FIELD SUPPORT, O-LEVEL, DEBRIEF, I-LEVEL, AFLC SUPPORT ANALYSIS, D-ENG, ANALYSIS	MX CONT, AFOTEC, D-LEVEL, DEBRIEF, I-LEVEL, O-LEVEL	CAMS, MODAS, MMICS, DMMIS, TICARRS, 3M, SEDS, 66-1	3.1.3.5, 3.1.4.5, 3.2.3.3
LOCATION OR LEVEL OF DIAGNOSTIC ACTION	MX CONTROL, ANALYSIS, CONTRACTOR FIELD SUPPORT	O-LEVEL, I-LEVEL, D-LEVEL		3.1.3.4, 3.1.4.4, 3.1.4.5, 3.1.3.5, 3.1.4.5, 3.2.3.3, 3.3.1, 3.1.2.4

Table 16 Data Matrices

FULL SCALE DEVELOPMENT PHASE
PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
RECONFIGURATION HISTORY	DESIGNER,O-LEVEL, I-LEVEL, ATE DEVELOPER, D-LEVEL, D-ENG	O-LEVEL, D-LEVEL, I-LEVEL		3.1.4.4, 3.1.4.5, 3.1.3.5, 3.1.4.5, 3.2.3.3
REPEAT/RECUR	O-LEVEL, ANALYSIS, D-ENG, I-LEVEL, D-LEVEL	DEBRIEF, ANALYSIS, O-LEVEL, I-LEVEL, D-LEVEL	66-1, CEMS, CAMS, TEMS, MODAS, G033	3.1.3.5, 3.1.4.5, 3.2.3.3
RESULTS OF EXPERT SYSTEMS	O-LEVEL, ANALYSIS, D-LEVEL, I-LEVEL, CONTRACTOR FIELD SUPPORT	DEBRIEF, D-LEVEL, O-LEVEL	66-1, CAMS, TICARRS, DMMIS	3.1.3.5, 3.1.4.5, 3.2.3.3
TEST REQUIREMENT DOCUMENT (TRD)	D-LEVEL AND I-LEVEL DEVELOPERS, USERS, FACTORY TEST DEVELOPERS, TPS DEVELOPERS	SYSTEM DESIGNERS, FACTORY TEST DEVELOPERS	CERTAIN COMMERICAL PROGRAMS	3.1.4.4, 3.1.4.7.1, 3.1.4.7.2, 3.1.4.11
TIME FAULT OCCURRED IN FLIGHT	O-LEVEL, D-LEVEL, I-LEVEL, CONTRACTOR FIELD SUPPORT	DEBRIEF, O-LEVEL	66-1, CAMS, CITS, TICARRS, DMMIS	3.1.3.5, 3.1.4.5, 3.2.3.3

Table 17 Data Matrices

PRODUCTION/DEPLOYMENT PHASE

PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
ACTION TAKEN CODE	MX CONT, ,ANALYSIS, O-LEVEL, D-ENG, I-LEVEL, D-LEVEL	O-LEVEL, D-LEVEL, I-LEVEL	AFM 300-4, SEDS, TICARRS, CAMS, TEMS, 66-1, 3M, MODAS, DMMIS	3.1.3.5, 3.1.4.5, 3.2.3.3
ACTIVITY IDENTITY CODE	I-LEVEL, ANALYSIS, D-LEVEL, D-ENG, D-LEVEL	O-LEVEL, MX CONT, I-LEVEL, DEBRIEF	CAMS, SEDS, MMICS, TICARRS	3.1.3.5, 3.1.4.5, 3.2.3.3
AIRCRAFT TAIL NUMBER	AFOTEC, MX CONT, CONTRACTOR FIELD SUPPORT, O-LEVEL, I-LEVEL, DEBRIEF, D-LEVEL, MAJCOM, D-ENG, ANALYSIS	AFOTEC, MX CONT, O-LEVEL, DEBRIEF	TICARRS, 3M, SEDS, MODAS, CAMS, DMMIS, MMICS, 66-1	3.1.3.5, 3.1.4.5, 3.2.3.3
AIRCRAFT/SYSTEM/ LRU BIT/BITE AT FAILURE	O-LEVEL, D-LEVEL, I-LEVEL, FIELD SUPPORT	DEBRIEF, O-LEVEL		3.1.4.4, 3.1.4.7.1, 3.1.4.7.2, 3.1.4.11
AUTO TEST EQUIP (ATE) TEST FAILED	D-LEVEL, D-ENG	I-LEVEL, D-LEVEL		3.1.3.5, 3.1.4.5, 3.2.3.3
COMPUTER PROGRAM IDENTIFICATION NUMBER (CPIN)	D-LEVEL	SYSTEM INTEGRATOR, TPS DESIGNERS	CAMS, DMMIS, TICARRS, AFTOMS	3.1.3.5, 3.1.4.5, 3.2.3.3

Table 18 Data Matrices

PRODUCTION/DEPLOYMENT PHASE
PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
CONNECTOR NUMBER/ID				3.1.3.5, 3.1.4.5, 3.2.3.3
CREW SIZE	MX CONT, ANALYSIS, TPS DEVELOPER, LSA, SYSTEM/SUBSYSTEM DESIGNERS	SYSTEM/SUBSYSTEM DESIGNERS, TPS DEVELOPERS	66-1, CEMS, SEDS, LSAR, 3M, CAMS, TEMS, TICARRS, DMMIS, MODAS, DO56	3.1.3.4, 3.1.4.4
DATE OF DIAGNOSTIC ACTION	CONTRACTOR FIELD SUPPORT, AFLC, ANALYSIS	O-LEVEL, D-LEVEL, I-LEVEL	66-1, TICARRS, D056, REMIS, CAMS, MMICS	3.1.3.4, 3.1.3.5, 3.1.4, 3.2.3.3,
DIAGNOSTIC ACCURACY	AFOTEC, ANALYSIS, D-ENG, MAJCOM, ASD, AFSC, LSA/LCC, AGE/TEST, EQUIPMENT DESIGNER, TRAINING EQUIPMENT DESIGNER	AFOTEC, D-LEVEL, I-LEVEL, O-LEVEL	TO BE CALCULATED FROM RAW DATA COLLECTED IN FIELD OR ESTIMATED BY DESIGN	3.1.4.4, 3.1.4.7, 3.1.2.4, 3.1.3.4
DIAGNOSTIC CODE - OPERATIONS/ MAINTNENANCE	AFOTEC, ANALYSIS, MX CONT, CONTRACTOR FIELD SUPPORT, O-LEVEL, I-LEVEL, D-LEVEL	AFOTEC, I-LEVEL, D-LEVEL, DEBRIEF, O-LEVEL	SEDS (AFOTEC)	3.1.3.4, 3.1.4.4, 3.1.4.5, 3.1.3.5, 3.1.4.5, 3.2.3.3
DIAGNOSTIC COST-DIRECT	ACQUISITION AUTHORITY, CONTRACTOR, DECISION AUTHORITY, LCC			3.1.3.4

Table 19 Data Matrices

PRODUCTION/DEPLOYMENT PHASE

PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
DIAGNOSTIC COST-INDIRECT	AFLC, ASD, LCC, CONTRACTOR FIELD SUPPORT	O-LEVEL, I-LEVEL, D-LEVEL, DESIGNERS/ENGINEERS	CALCULATED FROM RAW DATA	3.1.3.4.3
DIAGNOSTIC CRITICALITY	DESIGNERS /ENGINEERS, ACQUISITION AUTHORITY	DESIGNERS/ENGINEERS		3.3.1.4, 3.1.4.4, 3.1.4.4.1, 3.1.4.7.1, 3.1.4.7
DIAGNOSTIC DESCRIPTION	ACQUISITION, CONTRACTORS,, USER, AFLC	DESIGNERS/ENGINEERS	781s, 349s	3.1.4.3
DIAGNOSTIC EVENT	DESIGNERS /ENGINEERS, DECISION AUTHORITY	ACQUISITION AUTHORITY, CONTRACTOR, O-LEVEL, I-LEVEL		3.1.4.4, 3.1.4.5, 3.1.3.5, 3.1.4.5, 3.2.3.3, 3.1.3.4, 3.1.2.4
DIAGNOSTIC MANHOURS	AFOTEC, DESIGNER, MAJCOM, MX CONT, D-LEVEL, I-LEVEL, O-LEVEL	AFOTEC, D-LEVEL, I-LEVEL, O-LEVEL	MMICS, DO56, CAMS, SEDS, TICARRS	3.1.4.4, 3.1.4.7, 3.1.3.5, 3.1.4.5, 3.2.3.3, 3.1.2.4, 3.1.3.4
DIAGNOSTIC METHOD	O-LEVEL, ANALYSIS, I-LEVEL, LRU/LRM DESIGNER, AFLC SUPPORT, D-LEVEL, D-ENG, DESIGNER, LSA/LCC, TPS DEVELOPER	D-ENG, CONTRACTOR SUPPORT, O-LEVEL, D-LEVEL, I-LEVEL	MMICS, SEDS, CAMS, TICARRS	3.1.2.4.1, 3.1.2.4.2, 3.1.2.4.3, 3.1.3.4.1,3.1.3.4.2, 3.1.3.4.3
DIAGNOSTIC OUTCOME AND CODE	AFOTEC, AFLC, D-LEVEL,I-LEVEL, SUPPORT ANALYSIS, O-LEVEL, D-ENG, MX CONT, CONTRACTOR SUPPORT, DESIGNER, TE, TPS DESIGNER	AFOTEC, I-LEVEL, CONTACTOR SUPPORT, O-LEVEL, D-LEVEL		3.1.3.5, 3.1.4.4
DIAGNOSTIC TIME	AFOTEC, MAJCOM, I-LEVEL, MX CONT, D-LEVEL, DESIGNER, O-LEVEL	AFOTEC, D-LEVEL, I-LEVEL, O-LEVEL	MMICS, SEDS, CAMS, TICARRS	3.1.2.4, 3.1.4.4, 3.1.3.5, 3.2.3.3, 3.1.4.5

Table 20 Data Matrices

PRODUCTION/DEPLOYMENT PHASE

PRIMARY DATA

ELEMENT	NEED ORGANIZATION	GENERATING ORGANIZATION	SOURCE	MIL-STD
EQUIPMENT REQUIRED/ USED TO DIAGNOSE	O-LEVEL, D-LEVEL, I-LEVEL,	SYSTEM INTEGRATOR	LSAR, AFTOMS	3.1.3.4, 3.1.4.4, 3.1.4.5, 3.1.3.5, 3.1.4.5, 3.2.3.3, 3.1.4.11
EQUIPMENT IDENTIFIERS	I-LEVEL, D-LEVEL	D-LEVEL	66-1, TICARRS, SEDS, CAMS, AFTOMS, DMMIS, LSAR, 3M	3.1.3.5, 3.1.4.5, 3.2.3.3
FAULT CODE	DEBRIEF, D-ENG, D-LEVEL, , O-LEVEL, I-LEVEL,	DEBRIEF, D-LEVEL, O-LEVEL	66-1, CAMS, TICARRS, 3M, AFTOMS, DMMIS,	3.1.4.3, 3.1.4.4, 3.1.4.7, 3.1.3.5, 3.1.4.5, 3.2.3.3
FAULT DESCRIPTION	AFOTEC, I-LEVEL, O-LEVEL, CONTRACTOR FIELD SUPPORT, D-LEVEL, SUPPORT ANALYSIS, MX CONT, AFLC, DEBRIEF, DESIGNERS	AFOTEC, O-LEVEL, DEBRIEF,	SPECIFICATIONS, CAMS, MMICS, SEDS, CITS, FMEA, TICARRS , BIT RESULTS, TEMS, CEMS, TEST VECTOR RESULTS	3.1.3.4, 3.1.3.5, 3.1.4.5, 3.2.3.3
FLIGHT HOURS	DEBRIEF, ANALYSIS, CONTRACTOR FIELD SUPPORT	DEBRIEF	66-1, CITS, 3M, CAMS, MODAS, TICARRS	3.1.2.4, 3.1.3.5, 3.1.4.5, 3.2.3.3, 3.3.1
JOINT OIL ANALYSIS PROGRAM (JOAP) RESULTS	D-LEVEL, MX CONT, I-LEVEL, O-LEVEL	MX CONT, I-LEVEL, O-LEVEL	CEMS, TEMS	3.1.3.5, 3.1.4.5, 3.2.3.3

Table 21 Data Matrices

APPENDIX F

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APPENDIX G

80. VERTICAL TEST COMPATIBILITY

80.1 SCOPE. This appendix explains the Vertical Test Methods that should be used to ensure that test commonality and proper test tolerances are planned, implemented, and maintained between different testing levels throughout a system's life cycle.

Applying vertical test methods in an integrated design process approach will result in establishing and maintaining test compatibility and data correlation to support a hierarchical test structure. Vertical Test Methods must be implemented early during system design and test program development to ensure effective diagnostics and to minimize diagnostic problems caused by test incompatibilities.

80.2 APPLICABLE DOCUMENTS.

(**NOTE:** These documents are not to be applied contractually except to the extent that specific portions are cited in the requirement statements or verification statements.)

80.2.1 Government documents

80.2.1.1 Specifications, standards, and handbooks

AFGS-87256	Integrated Diagnostics
MIL-STD-1519	Test Requirements Document, Preparation of
MIL-STD-1839	Calibration and Measurement Requirements
MIL-STD 2077	Test Program Sets, General Requirements for
MIL-STD-2165	Testability Program for Electronic Systems and Equipment

80.3 RECOMMENDED DEVELOPMENT PROCESS. For the proper vertical test relationships to occur, vertical testability must be considered throughout the integrated design process. Each level of diagnostics must be developed with regard to its relationship to other levels of test (including on-equipment and factory). Vertical test methods prevent diagnostic gaps between levels of testing and ensure that testing at each level provides the optimum amount of coverage to minimize or eliminate major causes of CNDs and RTOKs. Once tolerance, test coverage and equipment compatibility are eliminated as problems, or at least reduced, then intermittent failures will be the main cause of CNDs and RTOKs. Special procedures may then be developed to identify and solve this problem.

Currently, the TPS developer takes the Test Requirements document(TRD) and other unit-under-test (UUT) source data and reviews it for accuracy and completeness. When the TPS developer is satisfied with this data, the test flow diagram, hardware design, and software design are developed. These are reviewed with the customer before test program development and integration testing begins. When the TPS is complete, it is reviewed again with the customer before formal demonstration and delivery occurs. The CMRSs are developed in parallel but with little interface.

APPENDIX G

The following paragraphs discuss the steps of the current development process. At the end of most steps are listed enhancements, those activities that should be performed in that step to properly address vertical test compatibility. Figures 32-34 illustrate this process, showing the roles of the system integrator and the system developer in development of TPSs and associated data.

The System Integrator/Customer generates the Critical Item Development Specification that should specify the following (Figure 32, Block 1).

Fault detection requirements
Support concept
Fault isolation requirements
Testability requirements
- Able to break feedback loops?
- Disable external control?
- Perform performance tests without probing?
- Perform diagnostic tests & fault isolation without probing?
- Etc.

The Subsystem developers should generate the following (Figure 32, Block 2).

Drawings
Category I CMRS source data
Analysis (testability)
Accuracy Performance Control Document (APCD) at interfaces
ATSs
ATPs
TRDs for each level of test should be developed concurrently

Enhancements

BIT TRD -- BIT should be specified in TRD format, which will be a part of the source data for the TPS developer
Vertical Test Traceability Matrix (VTTM) data should be developed along with the TRDs

The System Integrator/Customer should approve or disapprove the following data after reviews with both the subsystem developers and the TPS developers (users of the data) (Figure 32, Block 3).

Drawings
ATSs
ATPs
TRDs
Analysis results (testability)
APCDs
Preliminary CMRS

Enhancements

BIT TRD DATA
VTTM data

The TPS developer should receive and use the following items (Figure 32, Block 4).

Drawings, schematics, logic diagrams, etc., allow the TPS developer to understand the electrical circuit or mechanical system functions. It is necessary for the TPS developer to determine the UUT physical layout and characteristics in order to design mounting fixtures, specify connectors, and develop fault isolation aids.

ATSs are used to review specified factory test requirements, parameters, and tolerances, comparing all of this data with the TRD. Part B aids the TPS engineer in discovering any conflicts to resolve. It is also important source data for ensuring TPS compatiblity with factory test requirements.

ATP review allows the TPS engineer to verify that the ATS requirements are being met in the factory test environment. If they are not, is the ATS and TRD Part B correct, or is there an error that needs correction before TPS development should begin? This data is also useful to ensure that the TPS design is compatible with the factory test environment.

TRDs are the traditional basis for TPS developmnent. It must be understood by all parties involved that TRDs are validated by TPS development. No source TRD is perfect. It can only be corrected and proven during TPS design and checkout. It is a major mistake for the TPS designer to be contracted to implement a TRD. The TPS designer must be contracted to meet the required test specifications (performance test, fault detection, fault isolatin, etc.) using the TRD as source data. It is important to the timeliness of the development process that the TRD be as accurate and as complete as possible. It is important for the TRD to be reviewed by all the cognizant parties in the maintenance environment for the UUT. This review should include the following parties.

TPS designer
TRD developer
UUT designer
Customer, preferably the engineering office assigned to the maintenance organization

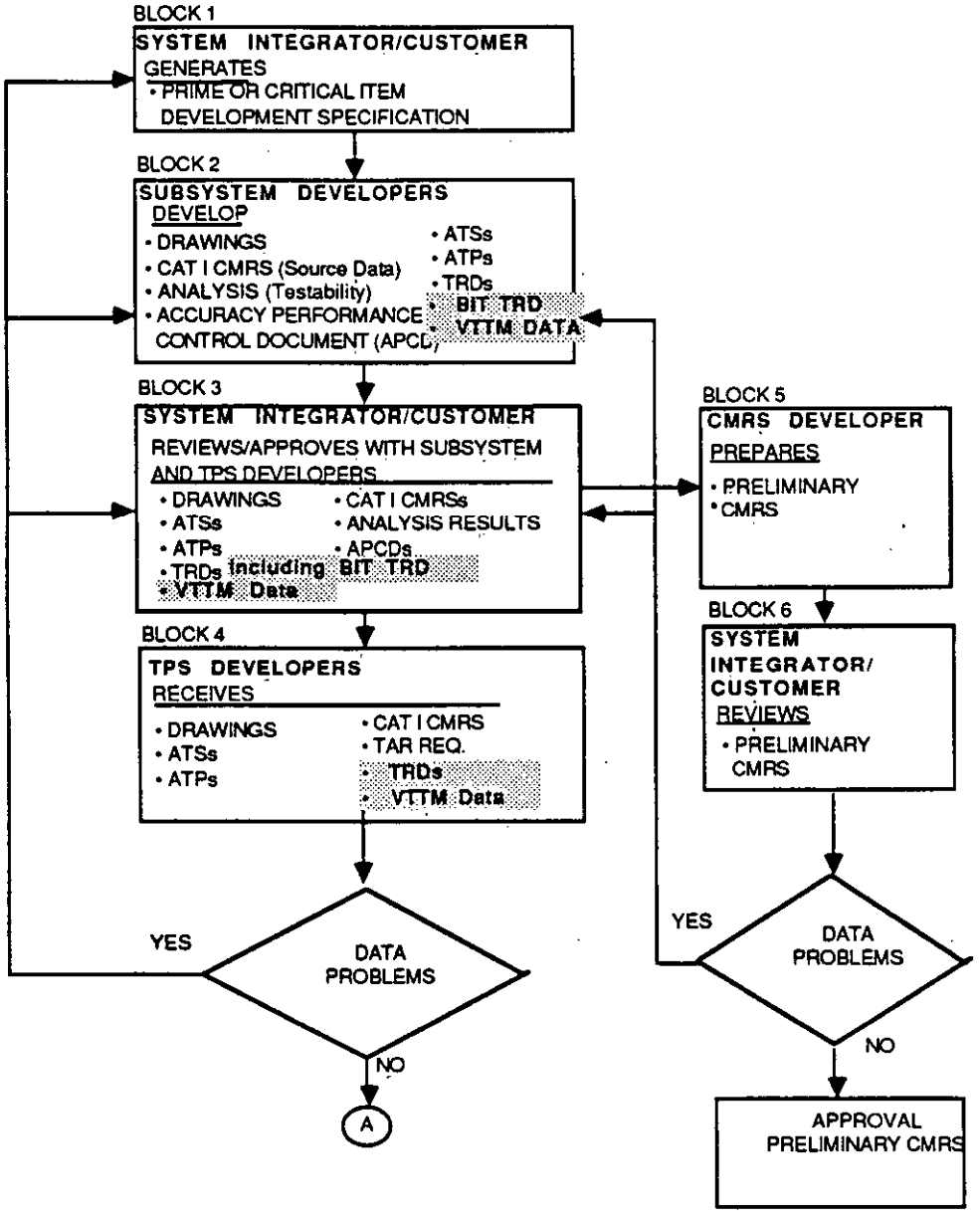


Figure 32 Recommended Diagnostic Development Flow

TRD review criteria should include the following.

Part A. Part A data should be reviewed to determine test equipment requirements. What automatic test equipment is the right choice for this UUT? If the test specifications already exist, is the UUT compatible with the ATE? What are the compatibility problems and how can they be solved?

Part B. Part B performance tests should be reviewed to ensure that complete end-to-end tests are specified and are capable of verifying that the UUT is compatible with the unit's next higher assembly. This review can determine if the fault detection

specificaitons are being met. The review can also determine if the specified tests are valid and adequate.

Part C. The diagnostics section of the TRD should be reviewed to determine if the fault isolation tests meet the specified requirements.

Are the tests sufficient to repair the UUT?
Do the tests meet the fault isolation requirements called out in the Critical Item Specification for the UUT?
Can the diagnostic means (probing allowed or not, etc.) meet the testability requirements in the Critical Item Specification?
Are the tests valid?

If deficiencies are discovered, they must be corrected.

Category I CMRS
CMRSs are currently developed to describe SE calibration requirements
Test Accuracy Ratio (TAR) data

Enhancements

VTTM data
BIT TRD data

If problems are detected in any of the data received by a TPS developer, the problems are resolved with either the subsystem developer or the system integrator.

Following development of the Category I CMRS source data, the CMRS developer should develop the preliminary CMRS (Figure 32, Block 5).

The system integrator/customer should review and approve the preliminary CMRS. If data problems are found during the review, the subsystem developer should resolve the problems (Figure 32, Block 6).

The TPS developer should use the available source data to design the ITA, to develop a test flow diagram for the software design, and also to update the VTTM. At this point in the development phase, the following events occur (Figure 33, Block 7).

The ITA design is determined in a block diagram conceptual design showing UUT/ITA/ATE interfaces
Software design is at the level of are the High Order Language constructs adequate for testing, or, are lower level routines required, etc.
The Test Flow Diagram (TFD) is developed as an ATE independent flow chart of the performance and diagnostic test requirements.

Enhancements

The VTTM is also updated at this time

The System Integrator/Customer should review the proposed TPS conceptual design and test philosophy with the TPS developer. The TPS designer provides the following UUT data to the reviewing entity (Figure 33, Block 8).

Drawings, including schematics, mechanical layouts, test point locations, etc

TRDs, including UUT TRD, next higher assemlby TRD, and any applicable BIT description TRD
Calibration Measurement Requirements Summary (CMRS) including the test accuracy ratio (TAR) requirement
Acceptance Test Specification

The TPS designer supplies the following TPS design data.

Interface Test Adapter (ITA) or manual test equipment (MTE) conceptual design drawings, including any requirements for ancillary equipment and description of ATE functions being utilized
Test flow diagrams which describe the proposed performance and diagnostic tests as well as a description of the proposed test philosophy.
Vertical Test Traceability Matrix (VTTM)

The UUT data is used by the customer engineers to become familiar with the UUT itself. The drawings, schematics, component layouts, etc., allow the engineer to evaluate not only the TPS designers hardware design, but also the test philosophy, including use of and accessibility of test points. The TAR can allow the reviewer to determine the proper usage of the ATE or MTE. The TRD can be compared to the test flow diagram to determine any deviations that must be discussed and resolved, rememebering that test requirements must be met, not TRD requirements. The ATS can be compared to the test flow diagram to ensure compatibility with factory test. The CMRS and TAR data is taken to review the hardware design and test equipment assets to ensure that the accuracy of this equipment supports the test requirements. The VTTM is used to cross reference relationships between levels of test to ensure complete test coverage and is used as an aid in analyzing tolerance compatibility between levels of test. The customer engineers and TPS design engineers must resolve any problems uncovered during this review before starting EET. Areas in which agreement must be reached are as follows.

Is the test philosophy sound?
Is the fault detection specification met?
Is the fault isolation specification met?
Will the test equipment accuracy support the test requirements?
Is the testing compatible with other levels of test as well as factory?

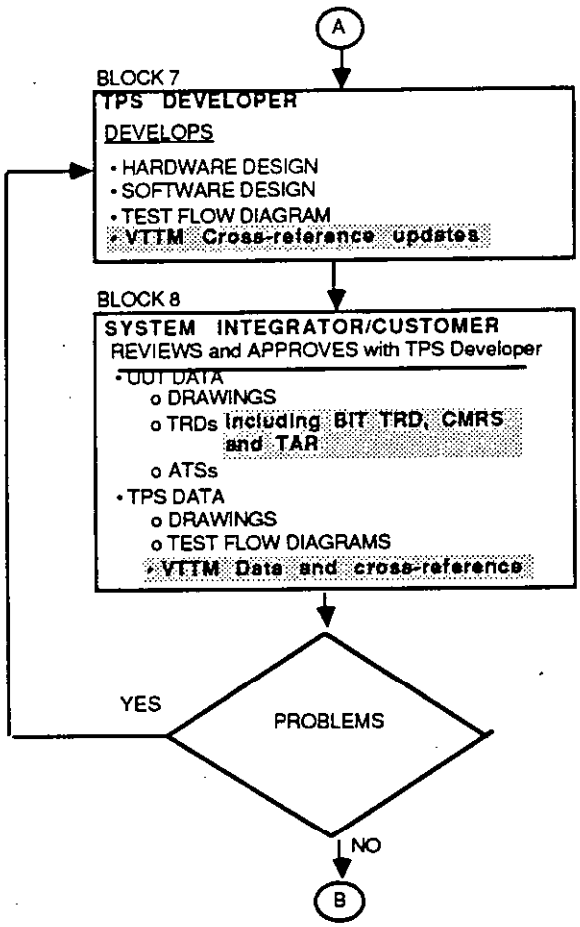


Figure 33 Recommended Diagnostic Development Flow (cont'd)

TPS development continues as follows (Figure 34, Block 9).

Detailed hardware design and fabrication occur
Test program development and syntactical checkout occurs
Engineering Evaluation Testing (EET) occurs
This is the meat of the development process.
Performance tests are verified.
Diagnostic tests are verified through fault insertion.
TRD deficiencies (as well as ATE deficiencies) are identified.
TPSs are verified that they can detect faults and isolate so that the item can be repaired and verified compatible with the next higher assembly, as well as meet specification requirements

APPENDIX G

Following development of the TPS, customer and TPS development engineers should review it to determine if it is ready for formal demonstration. This review should look at UUT data as well as at TPS data. At this point, the TRD has been corrected, updated, and proven by TPS development. The test equipment engineer should supply engineering notes and data that support the reasons for TRD update. The customer and developer should agree that the new TRD that is implemented by the TPS or manual test procedure is correct and meets all the maintenance specifications. The following topics should be discussed (Figure 34, Block 10).

Were pre-development review agreements adherred to?
Are performance test requirements that verify compatibility with next higher assembly met?
Are the fault detection/fault isolation specifications met?
When the source TRD and /or ATS were deviated from, were these deviations justified? Was the justification and supporting data documented in the engineering notebook?
The Vertical Test Traceability Matrix (VTTM) is used to verify test coverage between levels of test. Is the test coverage complete?
Is the tolerancing between levels of test correct?
Using the CMRS including the TAR, are the test setups accuracy supporting the test tolerancing requirements?

The CMRS developer should prepare the final CMRS at the same time that the TPS developer is completing Test Program Developement and Engineering Evaluation Testing (Figure 34, Block 11).

The system integrator/customer should review and approve the final CMRS. If problems exist, the CMRS developer is responsible for resolving the problems (Figure 34, Block 12).

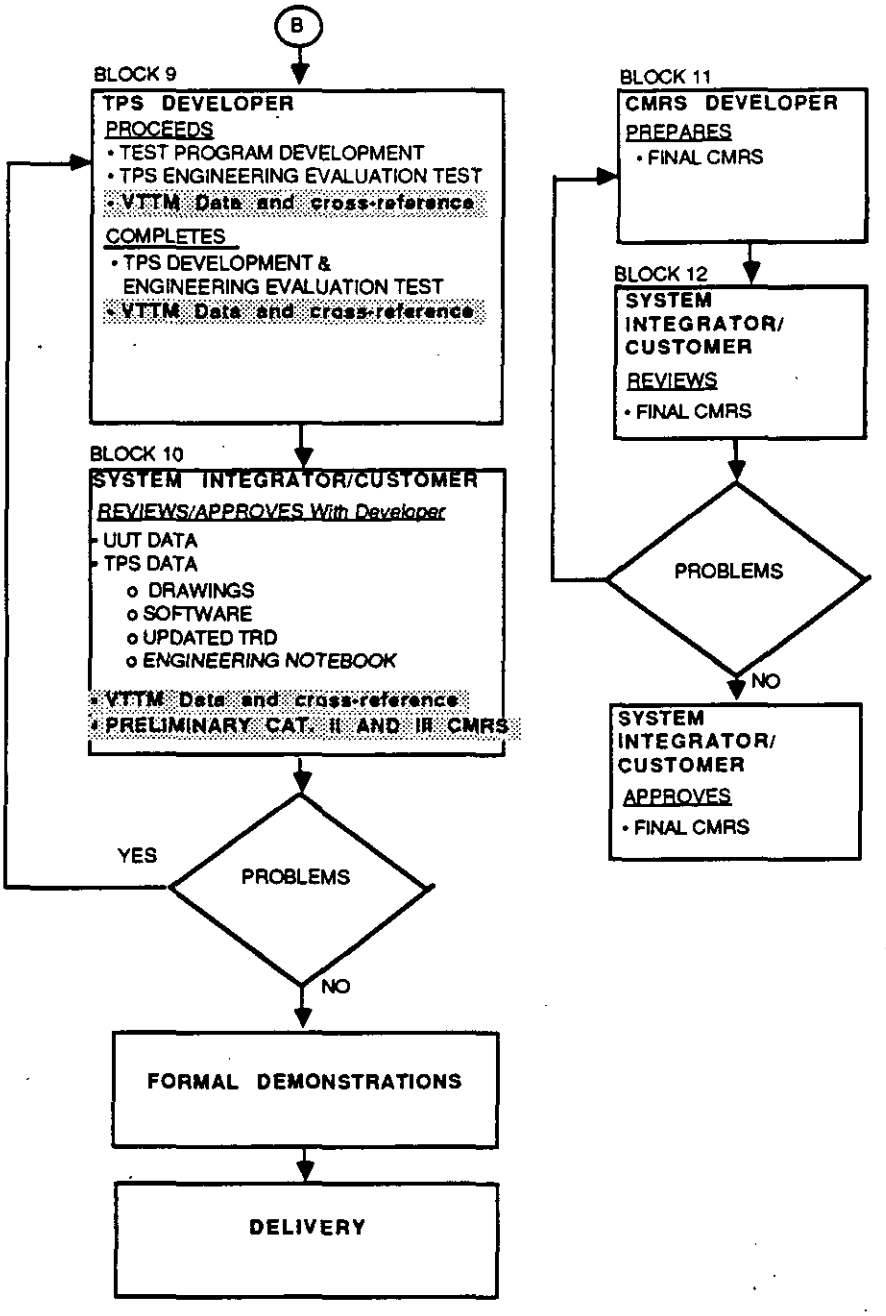


Figure 34 Recommended Diagnostic Development Flow (cont'd)

80.4 CURRENT PROCESS DEFICIENCIES/RECOMMENDED CORRECTIVE ACTION. This section addresses some deficiencies of current processes in achieving vertical test compatibility and recommends corrective actions. Areas addressed are the following.

1. Built-in-test (BIT) documentation
2. Traceability between levels of test
3. Test Requirements Document (TRD) / Test Program Set (TPS) compatibility
4. Test equipment compatibility

5. BIT re-execution
6. TRD/TPS review process

This section also addresses the data flow/approval process and recommended improvements which would enhance the Vertical Test Methods process.

80.4.1 BIT Documentation. BIT implementation is required by AFGS-87256, 3.3.1.3 to be documented in Test Requirements Document (TRD) format for use by the test program set (TPS) designers.

Deficiency of current process. BIT specifications are required by MIL-STD-2165, but formal documentation is not a requirement. Since BIT is normally developed by the system designers and explained during design reviews, it is rarely documented on a test-by-test basis. In attempting to minimize added hardware required for BIT, innovative techniques are often used. Also, BIT software is integrated with the system Operational Flight Program (OFP) and may make use of portions of the OFP. Unless the entire BIT is well documented and considered when OFP updates occur, these updates may invalidate parts of the BIT, causing the coverage of BIT to be less than was originally intended.

Recommended corrective action. BIT should be specified in MIL-STD-1519 TRD format, and after implementation, the TRD should be updated. As shown in Figure 50, the diagnostic design allocation process feeds the vertical test traceability matrix (VTTM) to create a diagnostic roadmap. The subsystem TRD describes the test requirements which are implemented as BIT (or O-level tests) and used to diagnose the subsystem and isolate to a LRU (or LRM). The LRU TRD describes the test requirements which are implemented as I-level TPS (or manual tests) required to diagnose to the SRU level. The SRU TRD describes the test requirements implemented at D-level TPS to diagnose to the component level. The VTTM cross references related tests between these levels of maintenance. These relationships can be used as described in 80.4.4. When BIT data is cross-referenced with off-equipment tests in the TRDs, vertical test relationships are shown that can be used to (1) verify test coverage, (2) make the off--equipment designer aware of on-equipment capability, and (3) resolve tolerance problems between on- and off-equipment tests.

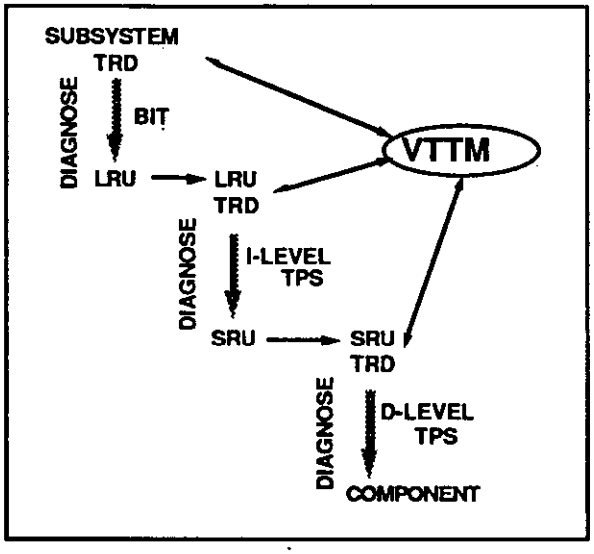


Figure 35 Diagnostic Design Allocation Process

80.4.2 Test traceability. Requirements to develop and establish an approach for achieving vertical test traceability are established in 3.1.3.2, 3.1.3.4, and 3.1.4.2.

Deficiency of current process. Currently, there is no requirement to establish traceability between levels of diagnostic test. In the current diagnostic development and implementation scenario, TRDs and TPSs for different levels of testing are developed by different groups at different times, and each level is often developed with little regard to adjacent levels of test. When BIT is not documented, off-equipment diagnostic designers often do not take advantage of its re-execution (when it is designed so that it can be). Intermediate level tests are developed with no regard to depot, and depot level tests are developed without regard to intermediate. Knowing the relationship of the tests between each level of diagnostics is important for the implementation of good vertical test.

Recommended corrective action. A Vertical Test Traceability Matrix (VTTM) should be developed that would document the test relationships between levels of diagnostic tests. The VTTM requirement is established in 3.1.4.2 and 3.2.3.2, and in AFGS-87256. A detailed example is shown and explained in 80.6.2. Figure 35 illustrates how the VTTM fits in the diagnostic design allocation process.

80.4.3 TRD/TPS compatibility. Test Requirements Document development is defined by MIL-STD-1519.

Deficiencies in TRD AND TPS development. TRDs document the interface requirements of the UUT; the loading and environmental requirements; the performance test requirements, which verify that the UUT meets its next higher assembly requirements; and the diagnostic test requirements, which are needed to meet the UUTs fault isolation requirements. When TRDs and ultimately TPSs are developed (or manual test equipment and T.O.s), the tolerance in the TRD and TPS must support both the operational requirements and the proper cone of tolerance. TRDs can only be proven through TPS (or manual test equipment) development and validation. If the test tolerances do not support the UUTs operational requirements, the tests will not meet the intended purpose of verifying the UUTs ability to operate in its next higher assembly successfully. If the tolerances do not fall within the proper cone of tolerance, vertical test incompatibilities will occur. If the TRD, and ultimately the TPS, do not have complete test coverage, vertical test incompatibilities will occur.

If the TRD is correct, but the TPS implementation is incorrect due to the improper use of equipment and instrumentation whose tolerances do not support the operational requirements, improper testing will occur.

Recommended corrective action. For the TRD to be implemented properly into a TPS (or manual test set), the proper Test Accuracy Ratio (TAR) specified in the CMRS must be adhered to. By using the CMRS and the TAR, the TPS developer can ensure that the test equipment accuracy supports the test tolerance requirements of the TRD.

One means of achieving vertical testability is to use a cone of tolerance. A cone of tolerance, or V (Figure 35) should be established so that the range of tolerances become increasingly tighter or smaller as the item passes through the levels of test from the flight line through the factory.

As illustrated in Figure 38 the operational level test requirements must ensure the unit meets operational requirements. A range of acceptable values is selected whose outer limits are within the operational requirements and whose range is controlled by test equipment tolerances and accuracies. The inner limits of this set of values becomes the requirement that must be met at the next level of maintenance to ensure operation within the next higher assembly. In other

words, the inner or narrower limit of tolerance for the subsystem value becomes the operational requirement for the LRU to be tested at the intermediate level. Similarly, the narrower limit of tolerance for the intermediate level must be compatible with the outer limits of the depot capability. With modern test equipment accuracies and capabilities, performing a test "the best you can" at one level of maintenance can produce tolerance and accuracy requirements for the next level that are more difficult and expensive or even impossible to meet. Thus, the tendency to make measurements and tolerances as tight as possible must be balanced against the capabilities of other levels of maintenance. The proper preparation of CMRSs and consideration of the effects of the appropriate TARs help ensure difficult or impossible measurements and tolerances are not required.

A wider variance of acceptable measures is normally allowed at the flight line for various reasons including (1) inability to obtain precise measurements due to inadequate or inappropriate test equipment, (2) expected but acceptable wear and variances from operational use, and (3) prohibitive cost for precise measurement equipment at that level of maintenance due to manpower, space, dollars , or weight. As the item progresses through the cone of tolerance and, hence, through the levels of maintenance, the acceptable measures, tolerances, etc., should become narrower due to increased test capability or repair capability, as well as the requirement for each unit to be able to perform within its next higher assembly.

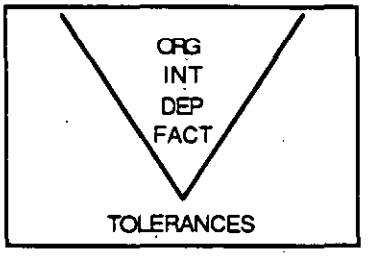


Figure 36 Levels of Test within Cone of Tolerance

TRD steps must be cross-referenced between levels of test to ensure test coverage and to perform analysis to ensure that tests fall within the cone of tolerance.

Operational parameter and tolerance data as well as loading and environmental data are translated into TRD requirements. This data must fall within a cone of tolerance as shown in Figure 36 to ensure test compatibility.

Figure 37 illustrates an example of a proper cone of tolerance. A function on an LRU is designed to produce a 5 VDC $\pm$ 0.5 VDC nominal discrete at the organizational level. The tolerance is tightened to 5 VDC $\pm$ 0.4 VDC at the intermediate level. If this were carried through to remaining levels, the $\pm$ VDC would continue to decrease. Thus, a test measurement of 5 VDC $\pm$ 0.5 VDC would pass at the organizational level but would fail at the intermediate level. Anything falling out of tolerance at the organizational level would also fail at the intermediate level and would confirm the failure. This cone provides some leeway for actual conditions at the organizational level, such as wear and tear, changing environmental conditions, training and skill of the technician, quality and capability of the test equipment and inability to maintain total control over test conditions. This can be applied to any system, such as inner or outer diameters of bearings or struts, lenghts of cracks or delamination, allowable travel of moving parts/controls, leaks (drip rate), or fluid/gaseous flow rates and temperatures.

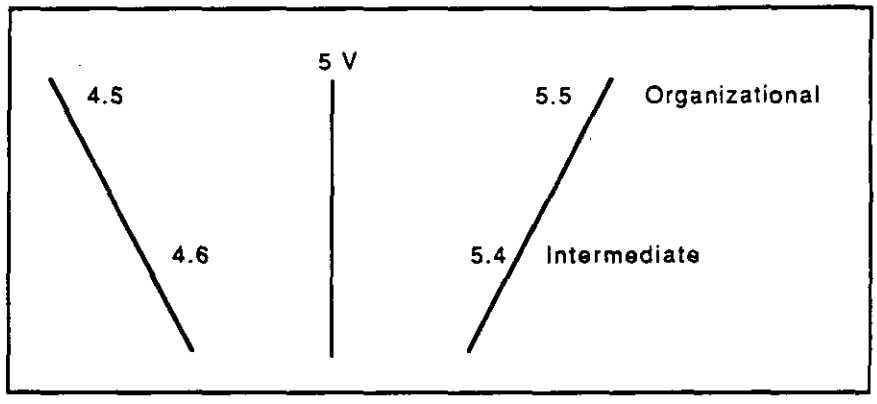


Figure 37 Correct Cone of Tolerance

Figure 38 illustrates an incorrect, but very possible, cone of tolerance. Using the same LRU as described in Figure 52, the tolerances remain the same at the organizational level (5 VDC $\pm$ 0.5 VDC). However, the tolerances at the intermediate level are now 5 VDC $\pm$ 0.6 VDC. Thus, the LRU could fail its test at the organizational level with a measurement of 5.55 VDC. However, when the unit is tested at the intermediate level, its measurement of 5.55 VDC would be within tolerance and, thus, would result in a retest okay (RTOK). This unit could conceivably continue to "bounce" between the levels of maintenance as a bad actor, costing manhours, aircraft downtime, and needless tying up of other valuable resources.

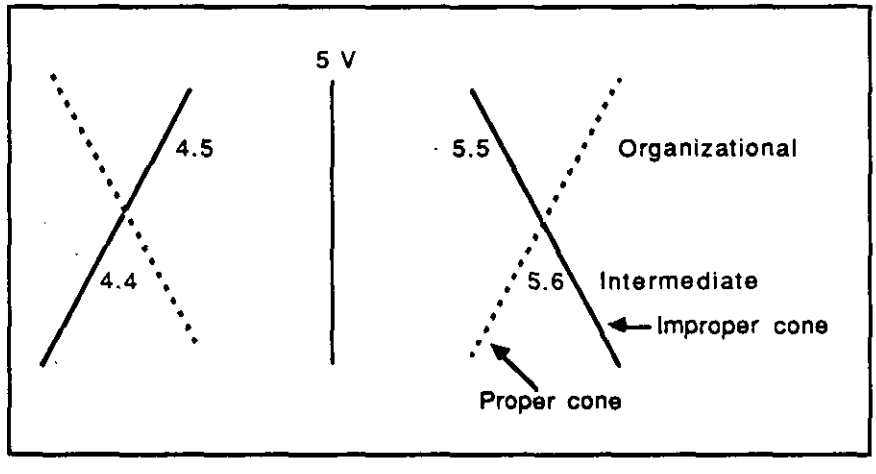


Figure 38 Incorrect Cone of Tolerance

Requirements

Environmental effects should be established during qualification testing and become a part of the tolerance budgeting in the TRD. If failed conditions can cause the item to be more sensitive to environmental conditions than normal, these environmental conditions should be specified in the TRD.

Power requirements needed to power up the item for operation, normally applied throughout testing, must be specified

The signals that are needed to performance test and to diagnose the UUT must be specified. The performance tests verify that an item can or cannot meet the requirements of its next higher assembly. The diagnostic tests fault isolate the item to its specified level.

Measurements that are needed to verify and diagnose the UUT are required.

Test critical loading requirements must be specified.

80.4.4 Test equipment compatibility.

Deficiencies in test equipment compatibility. When different test equipment is used, different results are often seen for what are intended to be the same tests. Besides the obvious differences in instrument accuracies, these different results are caused by such factors as different impedances, sample rates, resolution, bandwidth, and environmental conditions. For many devices, such as spectrum analyzers, waveform analyzers, and sampling oscilloscopes, different software implementations, or algorithms, cause different responses to noise, overshoot, etc. Because of these differences, particular care must be taken when comparing the range of acceptable pass/fail values applicable to similar tests performed by different test equipment.

Test equipment incompatibilities can be a source of vertical test problems because the test tolerances become artificially skewed by test equipment inaccuracies and incompatibilities.

Recommended corrective action. The best way to ensure test equipment compatibility is to use the same test equipment whenever it is possible. The same equipment may be used at the factory and the Intermediate level for LRU testing. The same equipment may also be used for SRU testing at the factory and at the Depot. This use of the same equipment for the same type testing in different locations also reduces the duplication of effort required to develop separate test equipment and TPSs, potentially reducing costs.

The same principle applies in the use of the same tests between levels. This is especially applicable to the re-execution of BIT. If BIT is not used at multiple levels, the test capability of BIT must be duplicated in the TPS at the appropriate levels. This could be a significant increase in cost and effort.

APPENDIX G

Figure 39 depicts how the allowable ranges of values of one test should be related to those from another level of test. Test tolerances, to allow for basic tolerance and design, must allow for test uncertainties dependent on instrument error, environment, etc.

Instrument error allocations must be specified in CMRS (including TAR data). Environmental error allocations must be determined during qualification testing.

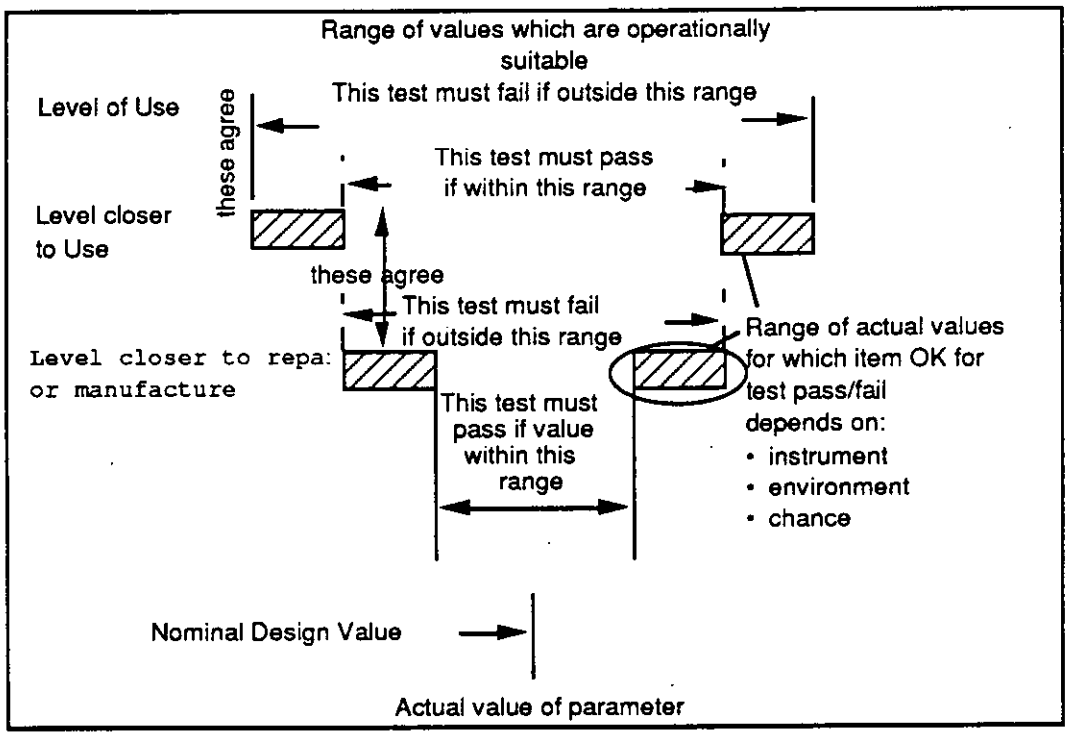
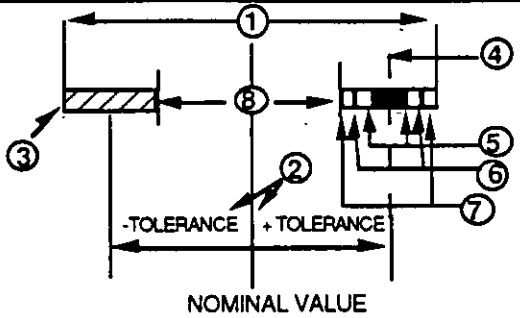


Figure 39 Tolerance Relationship Betwen Levels of Test

Figure 40, Sources of Measurement Inaccuracies, depicts how different sources of inaccuracy are summed to determine the allowable range of values for pass/fail.



① Range of values which are operationally suitable. Test must fail if outside this range. Supports Category I CMRS requirement

② Diagnostic tolerance range implemented by the TPS

③ Measurement uncertainty due to instrument accuracy limits, environmental conditions, and application of Test Accuracy Ratios

④ Nominal failure or tolerance limit

⑤ Range of tolerance uncertainty specified by TAR between Level I and Level II CMRS

⑥ Range of tolerance uncertainty specified by TAR between Level II and Level III CMRS

⑦ Environmental variations

⑧ Value that the parameter of the test instrument is set at to allow for physical aging, drift and/or environemental conditions

Figure 40 Sources of Measurement Inaccuracies

Tolerance established in the TRD must be tighter than the operational requirements. TRD tolerances plus the following tolerance budgets must sum within the operational requirement.

Uncertainty due to test equipment variation bounded by the TAR
Budget required to establish cone of tolerance
Budget established during UUT item qualification testing for environmental variations
Budget established for system aging (this would not be included in factory testing of new equipment)

Beyond use of TARs and proper test techniques, the best way to achieve compatibility of testing is by repeating test conditions. BIT can be re-executed if properly designed. Duplication of test equipment between the Intermediate and Depot levels is often not possible due to the difference in the types of UUTs tested (LRUs vs. SRUs). The conditions in which duplication of test equipment can be most fully taken advantage of are between the factory and Intermediate as well as between the factory and the Depot. Re-execution of BIT and

duplication of test equipment gives some ensurance that the tolerance budget required for test equipment uncertainty will be constant.

The cone of tolerance concept is most applicable for analog and microwave test applications. Digital testing also follows the cone of tolerance when the digital stimuli/responses are representations of analog signals. Pure digital testing of devices such as microprocessors follow a cylinder of tolerance concept. The digital patterns are either there or not. The signal levels must be within the specifications of the particular digital signal family.

80.4.5 Re-execution of BIT.

Deficiencies in BIT re-execution. BIT is not always executed during the various levels of off-equipment testing. If BIT is not re-executed for off-equipment testing, then the on-equipment BIT testing is not duplicated.

Recommended corrective actions. Duplicating test conditions as much as possible enhances vertical testability. When onboard testing uses BIT, off-board testing should include re-executing the BIT to duplicate the test conditions as much as possible.

- BIT should be re-executed during off-board testing in order to create the most commonality with onboard testing
- Off-board testing should not rely on BIT for complete testing to verify BIT operation
- The duplication of BIT and other test physical conditions is designed to reduce the test uncertainties illustrated in Figure 40.

80.4.6 TRD/TPS review process. TRD review is required, under the inspection provisions of MIL-STD-1519, to be performed by the supplier with the procuring activity reserving the right to perform or witness the review. MIL-STD 2077 requires TPS evaluation, including fault insertion for detection and isolation effectiveness, and submittal of an Acceptance Test Procedure (ATP) for each TPS.

Deficiencies in TRD and TPS review. Since review by the supplier is allowed, TRD and TPS reviews often do not include in-depth review for technical content and functionality. Thorough review of either a TRD or a TPS is an arduous process which may consume more time than the procuring agency is able or willing to allocate.

Recommended corrective actions. The procuring agency should require review of the product (TRD or TPS) by the developer, the information supplier, and the information user, as well as by the procuring agency. This review may be accomplished by circulating documents for review as well as holding review meetings. In-process reviews should be required as needed, based upon the size and complexity of the program and documents. A review meeting is suggested for TRDs, chaired by the procuring agency, and attended by designers (information suppliers), and TRD developers. Similarly, a review meeting is suggested for TPSs, again chaired by the procuring agency, and attended by TRD developers (Information suppliers) end users, and TPS developers.

80.5 DOCUMENTATION AND DATA REQUIREMENTS. The documentation and data requirements needed to establish vertical test methods are contained within those defined by Appendix F, the Technical Database. Guidance for using the key documentation related to establishing vertical test methods is provided here.

80.5.1 Test Requirements Document (TRD). Establishing test parameter values and tolerances is a logical process to ensure that if a unit passes a complete test, it will be capable of performing its required functions within its next higher assembly.

The required functions for a system, subsystem, LRU, SRU, or component are normally established through an allocation process. For instance, a radar system may have a requirement to detect a certain size target at a given range. This requirement will be allocated down to designers for the system as follows: modulator; pulse width (for target size discrimination), pulse repetition rate (for average power) transmitter; output power at the given pulse width, pulse repetition rate, and frequency, receiver; sensitivity and selectivity, antenna; gain, beam pattern and coverage, allowable sidelobes. These requirements will be further allocated to SRUs and even to components. The transmitter requirements will generate the transmitting device requirements (TWT, magnetron, solid state power devices, etc.) This will drive the power supply requirements, which will be allocated into rectifiers, regulators, transformers, or any other device in the power supply. The receiver requirements will drive local oscillator, mixer, signal pre-processing, and power requirements. Mechanical system designs are allocated in the same manner. For an engine to provide a given thrust, compressors must provide a given flow rate and pressure at a given RPM. Turbines must provide the drive power for the compressors and accessory drive at the proper RPM and temperature. The fuel system must provide proper pressure and flow.

Once the required functions are defined and the system design progresses, the individual units are tested to ensure they meet their requirements. After the system or subsystem is proven to meet its requirements and is deployed, maintenance and diagnostic testing is used to ensure the requirements continue to be met.

When the subsystem developer develops the TRD, the process requires the cooperation of hardware designer, software designer, BIT designer or integrator, and TRD developer. In some cases, all four of these functions might be the same person. In others, there may be varying combinations of these functions based upon the size of the effort. BIT should be documented by a TRD similar to any other test developed in order to ensure performance of the functions allocated during the design process is verified. The development of the test requirements to be contained in the TRD involves combining the knowledge of the various designers and integrators involved as well as schematics, drawings, specifications, and documents applicable. During development of the TRD for BIT, particular care must be taken to describe the input conditions and stimulus points used by BIT for those that are internal to the UUT and are not available at an external interface.

Once the initial TRDs have been completed, they should be reviewed by the system integrator with assistance as required from designers, TRD developers, and TPS developers. In the case of complex systems, in-process reviews during development of the TRDs may be beneficial. The purpose of the review should be to ensure that the functions allocated to the unit in the design allocation process are verified so that the capability of the unit to function in its next higher assembly may be verified as well as to ensure adequate fault isolation.

Development of the TPS would seem to be a straight-forward implementation of the TRD. In practice, the TPS developer often requires significant interface with TRD developers and designers and/or access to schematics, drawings, and specifications to match the unit to be tested to the selected test equipment. The TPS developer also must consider the TAR applicable to stimulus and measurement values required. He will consult the CMRS and test equipment specifications to ensure the capability to perform the tests contained in the TRD.

The system integrator, or customer, should review the TPS design with assistance as required from the TRD developer, TPS developer, and user. As with TRDs, in-process reviews during TPS development may be beneficial. As with TRD reviews, the purpose of TPS reviews should be to ensure that adequate capabilities are being developed for functional performance verification and fault isolation.

The final step in the development of TRDs and TPS is normally a formal demonstration of the capabilities of the TPS, using the test equipment, software, and procedures developed.

80.5.2 BIT Documentation. Built-in-test specifications are required by MIL-STD-2165 and should be specified in MIL-STD-1519 Test Requirements Document (TRD) format. An example of the format for documentation of BIT is shown in Figures 41 and 42.

Documentation of BIT is important for the following reasons.

1. Documentation makes source data available to Intermediate and Depot TPS designers (as well as factory test designers) to execute BIT to duplicate on-equipment test conditions.

2. When documented in the Vertical Test Traceability Matrix, test coverage can be verified between on-equipment test and the diagnostic levels of off-equipment testing.

FSD PHASE
EXAMPLE BIT DOCUMENTATION FOR VTM REQ.

BIT INFORMATION	PAGE TBD TRD NO. TBD REV TBD DATE TBD
TEST NO 212 UUT LPRF LRU TEST OBJECTIVE VERIFY L02 POWER OUTPUT	
MEASUREMENT DATA	TEST POINT 2A1J5 MEASURED VALUE 10 dBM HIGH LIMIT 11.5 dBM LOW LIMIT 8.5 dBM SUPPLEMENTAL DATA BIT INDICATES LOGIC "0" WHEN ABOVE TOLERANCES ARE MET, "1" WHEN FAILURE

TEST RESULTS	GO TO TEST	REPLACE
IN TOLERANCE	213	
OUT TOLERANCE		LPRF LRU

Figure 41 BIT TRD Detailed Test Information Sheet

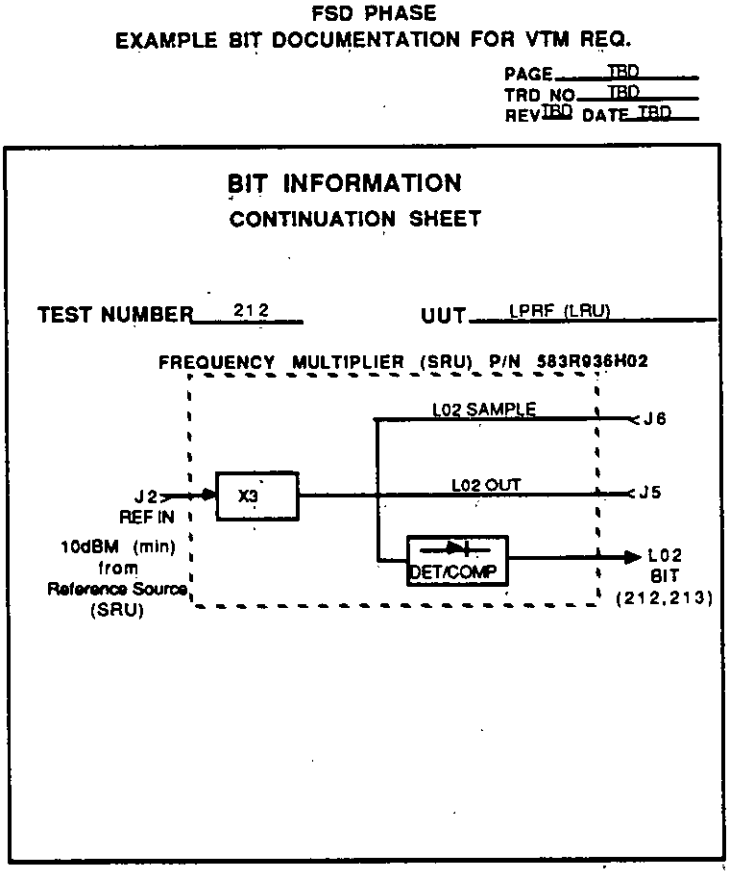


Figure 42 BIT TRD Test Description

80.5.3 Calibration Measurement Requirements Summary (CMRS)/Test Accuracy Ratios (TAR). The CMRS provides traceability from the operational requirement through the diagnostics to the National Institute of Standards and Technology (NIST). The TAR specifies how much more accurate the test equipment must be than the test requirements. Since test accuracy specifies the allowable range the test instrumentation can vary, this accounts for part of the test uncertainty budget.

80.5.3.1 CMRS. CMRSs should be prepared concurrently and in coordination with the diagnostics designer and not after the diagnostic development has been completed. CMRS are prepared per MIL-STD-1839 and consist of the following categories.

1. Category I - Parameter/tolerance requirements so that the item can support its next higher assembly.
2. Category II - Test equipment required to verify the item meets its Category I requirements.
3. Category III - Calibration equipment required to calibrate the Category II equipment, traceable to NIST

Test equipment adherence to the CMRS will establish that diagnostics support the operational requirements and provide traceability to the NIST. Implementing this at each level of test will

help ensure that testing is implemented properly. Figure 43 illustrates the traceability from the system to the NIST.

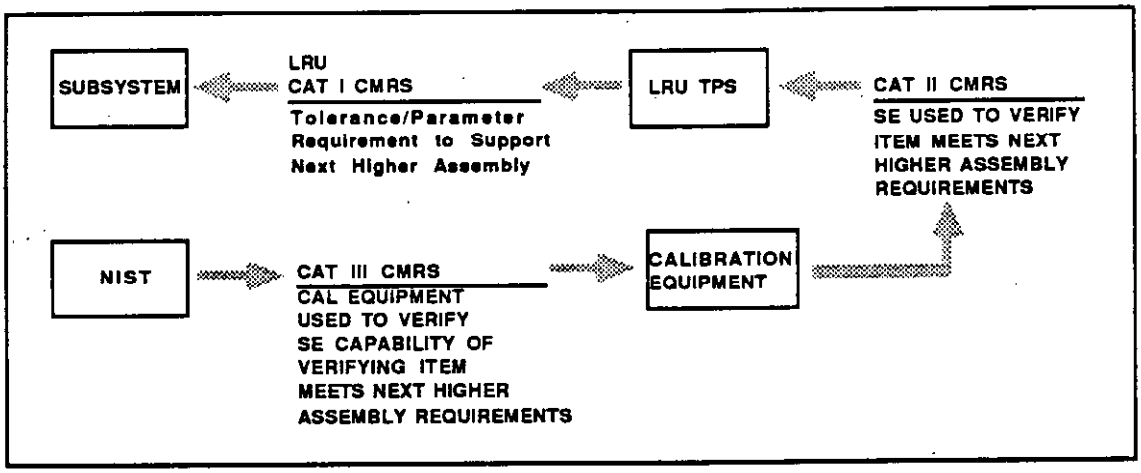


Figure 43 Parameter/Tolerance Traceability From System to NIST

80.5.3.2 TAR. The TAR establishes how much more accurate the test equipment must be than the parameters it is testing. Since the basic accuracy of any test set-up describes the range in which the readings may vary, this variation contributes to test uncertainty. If the TAR is not sufficient to support the test, the test tolerances can become artificially skewed.

Suppose a measurement required a DC voltage of 5 ± 0.1 volts and the measurement device has an accuracy of ± 0.2 volts. The test program would have the following ATLAS statement.

> MEASURE (VOLTAGE), DC SIGNAL, VOLTAGE RANGE 4.9 V TO 5.1 V, CNX HI TEST-PIN$

The meter reads 5.00 volts for a go condition, but the uncertainty range is ± 0.2 volts. Suppose in actuality that the voltage is 5.15 volts, which should be an out of tolerance condition. Reviewing the test program without reviewing the instrumentation accuracy and TAR requirements, it would appear that the test implementation was correct. In reality, the mis-use of the instrumentation resulted in skewed test results.

MIL-STD-1839 uses 4:1 as a guideline for TARs. Sometimes the tests performed contain state-of-the-art technology in which 4:1 cannot be supported. On the other hand, a TAR specified too stringently can be difficult to implement. As an example, if 10:1 is used, the requirement would be 10:1 between Categories I and II and 10:1 between Categories II and III, which would be 100:1 between Categories I and III.

80.5.4 Vertical Test Traceability Matrix. TRDs should be developed concurrently using an end to end test philosophy of complete diagnostics from on-equipment through each level of off-equipment testing. A Vertical Test Traceability Matrix (VTTM) should be developed that would document the test relationships between levels of diagnostics. As an example, BIT might test Function A, Intermediate tests 1, 2, and 3 might cover Function A, while Depot tests x, y and z might cover Intermediate test 1. What is being proposed are cross reference matrices which would document these relationships. The advantages of this are listed below.

1. Using this data during TRD reviews, TPS reviews, and other diagnostic design reviews can ensure total test coverage
2. The establishment of this requirement forces the diagnostics designers to consider multiple levels of test
3. This data could be used to allow faster diagnostics by referencing the VTTM at the next level of test to indicate which tests are related
4. This data along with a maintenance database system can be used to isolate and correct RTOK problems

Figure 44 is an example of how the VTTM might appear. This example is of an updated TRD following TPS development. This TRD/VTTM would be for the Low Power RF (LPRF) LRU of the F-16 A/B. The shaded area at the top of the page identifies the Intermediate Test Program Computer Software Configuration Item (CSCI) number. The shaded area at the bottom of the page indicates the BIT sequence number (referred to"MFL" on the F-16 A/B), the Intermediate Test Program step number, the SRU fault isolated to at the Intermediate, and the Depot Test Program step number. This table is designed to provide traceability of related tests between the levels of maintenance.

APPENDIX G

VERTICAL TEST TRACEABILITY MATRIX CROSS-REFERENCE

LOW POWER RADIO FREQUENCY (LPRF) LRU
LRU P/N: 681R319G01,G02,G03,G04;
681R622G01,G02,G03,G04
AIS ATE: RADIO FREQUENCY TEST STATION

LINKAGE TO O-LEVEL		LINKAGE TO D-LEVEL	
MFL CODE	AIS TEST PROGRAM NO. 1674-4034P1H TEST STATEMENT NO. (LRU)	TEST PROGRAM NO. (SRU)	TEST STATEMENT NO. (SRU)
	121420	1674-5009PA	135300
	121460	1674-5009PA	085300
	121460	1674-5009PA	105300
	121460	1674-5009PA	125300
	121460	1674-5009PA	145300
	121501	1674-5009PA	075500
	121501	1674-5009PA	095500
	121501	1674-5009PA	115500
	121501	1674-5009PA	135500
	121520	1674-5203PB	010150
201	130260	1674-5005PA	008400
201	130440	1674-5009PA	008620
201	130701	1674-5009PA	008000
	130701	1674-5009PA	008640

Figure 44 Example Vertical Test Traceability Matrix

The following are important points about the VTTM and TRDs.

TRDs should be developed as concurrently as possible, as well as the VTTM, to indicate test relationships between levels of test. (This requires that diagnostics be considered as an entity, not many stand-alone pieces.) (TRDs include BIT.)

The system integrator should supply the BIT TRD.

The LRU and SRU designers should supply Intermediate and Depot level TRDs.

The TRD developers should develop the VTTM.

The BIT designer should develop and update the BIT TRD.

The TPS designers should develop and update Intermediate & Depot level TRDs.

The TRD developers should update the VTTM.

80.6 VERTICAL TEST PROBLEM SOLVING. When CND or RTOK problems are identified, the first step in problem solving is to identify the test or function that failed or was reported as failing. At the equipment or systems level, this is often expressed in operational terms. For off-equipment testing, this may be expressed as a failure of a particular test. This data may be recovered from operator write-ups and debriefing or from maintenance databases, such as CAMS or REMIS.

80.6.1 Can not duplicate (CND). The next step is to verify the failure. If the failure cannot be duplicated, it is referred to as a CND. If BIT is involved with the CND, the improved documentation of BIT per the GIMADS guidelines will be beneficial in the analysis of the CND problem. If the CND item is sent to the next level of test and if the failure is confirmed, the VTTM, which documents test relationships between levels, can be used to analyze the diagnostic problem between the two diagnostic levels by investigating the tests expected to fail.

80.6.2 Re-test OK (RTOK). If a failure is confirmed, the item will be sent to the next level of maintenance. If the item passes this level, it is referred to as an RTOK. When a RTOK occurs, the VTTM can be used to identify the test or group of tests out of which a failure should have occurred. These tests, the test equipment involved with these tests, the environmental conditions, etc., can be investigated in order to correct the problem.

80.6.3 Additional testing. If the failure cannot be confirmed or the tests at both levels of diagnostics appear compatible, further testing should be performed to attempt to confirm the failure or further identify the problem. This could also include increased testing, or testing under environmental stress, to identity any intermittent failure.

80.7 CONCLUSION. Application of the methods recommended by the GIMADS process can improve diagnostics, and reduce diagnostic maintenance, spares, manpower, and equipment costs through the reduction of CNDs and RTOKs and improved diagnosis of intermittent failures.

APPENDIX H

90. INTEGRATED DIAGNOSTICS CONCEPTS

The scope of the ID concepts, requirements verification, the diagnostic mix elements, and the process interfaces are described below.

90.1 SCOPE. This appendix covers topics of interest to individuals who either task or accomplish programmatic diagnostic activity.

90.1.1 Purpose. This appendix provides information about basic ID concepts to establish a common understanding among users of this document.

90.1.2 Application. The basic ID concepts covered in this appendix have caused confusion or controversy due to the different perspectives and opinions created by the infancy of ID as a subject and by the diversity of Government and industry cultures addressing ID. Applying these concepts should provide a basic foundation upon which to address ID issues.

90.2 APPLICABLE DOCUMENTS.

(NOTE: These documents are not to be applied contractually except to the extent that specific portions are cited in the requirement statements or verification statements.)

90.2.1 Government documents

90.2.1.1 Specifications, standards, and handbooks

AFGS-87256 Integrated Diagnostics

(See 90.5.2-90.5.4 for listings of reference documents and matrices showing their relationship to various aspects of ID).

90.3 REQUIREMENTS VERIFICATION. For a requirement to be meaningful, there must be a way to verify that it has been accomplished. There are many ways to perform verifications, some more suitable than others under certain conditions. This section provides guidance that can help develop cost-effective verification plans that drive the selection of specific verification methods for design requirements (see AFGS-87256 for generic design requirements and verifications).

90.3.1 Verification reasons. There are four reasons for verifying requirements: validation of requirements, in-process, qualification, and operational.

Validation of requirements. Validation of requirements investigates whether or not requirements that have been written adequately describe what must be done to achieve their objective. Validation usually consists of evaluating requirements, and the logic used to create them, to ensure that the requirements are needed, and that they cover all aspects of the higher level requirements or needs that caused them to be created. In most cases, the proof of the relationship should be recovered and documented from the requirement development processes, such as the requirements derivation and allocation processes described in Appendix B. Validation of requirements ensures that, when all the requirements of a design level are satisfied, the associated higher design level requirements will be met.

In-process verification. In-process verification considers not only the validity of the requirements but also how likely it is that the requirements will be met. In-process builds upon validation by assessing the element of risk involved in the current design. It is necessary to analyze the design solutions that have been proposed for meeting the requirements, at whatever stage of design they are in, to see how likely it is that the solutions can be achieved. The risks associated with these solutions can then be factored together to determine an overall risk for the design at a given point. In-process verification may be used as a management review to assess program risk, usually in early development phases or between program milestones. It indicates how likely it is that a design, at its current level of definition and direction, will meet its goals.

Qualification verification. Qualification verification (sometimes termed production or development verification) determines if an item meets its specifications. It is normally performed after an item has been produced and usually involves operating the item. For complex items, however, it may not be possible to operate all desired features. Some projection of capability based upon what can be operated may be necessary.

Operational verification. Operational verification is used to show that an item meets specifications and long term goals in its operational environment, over a period of time. It provides feedback for changes to follow-on items, for modifications to existing items, or for building a database for future acquisitions. Operational verification is accomplished by monitoring (collecting data on) an item in the operational environment for which it was specified. The analysis of the observed results is used to verify that the requirements have been satisfied. Certain types of maintenance data are often used for this purpose. Generally, during the first 12 to 18 months, the data are not reliable in terms of operational verification because personnel are not yet accustomed to the item's proper use and procedures. This time lag is expected to be reduced when requirements and verifications are implemented from the top down in a concurrent engineering environment.

90.3.2 Ways to verify. There are two main ways a verification may be accomplished. An item or capability may be verified directly, as in verifying diagnostics on a radio by testing the radio. The capability may also be verified by inference, such as testing the components of a fire control system's diagnostics and validating the logic behind how the components fit together, to infer that the fire control system diagnostics will function properly in operation. For our purposes, verification by inference has two steps. The first step is verifying that the requirements and their rationale can lead to the item being verified. The second step is then verifying that the program is properly creating the components of the item.

There are four basic methodologies for performing verifications. These methodologies, in a progression typical of acquisition programs, are as follows.

Analysis
Inspection
Test
Demonstration

90.3.3 Selecting verification methods. When making plans that will influence the specific verification methods chosen for a program's diagnostic requirements it is important to consider how the reasons for verifying, and the ways to verify, influence available methodologies. Figure 45 shows how methodologies relate to ways.

	VERIFY BY INFERENCE		VERIFY DIRECTLY
	Requirements and Rationale	Components	Whole Item
ANALYSIS	X	X	
INSPECTION		X	X
TEST		X	X
DEMONSTRATION		X	X

Figure 45 Verification Methodology and Ways Relationship

The reasons why a verification is being performed may restrict the methodologies that can be used. Validation of requirements, by definition, is a partial verification. It is concerned with proving the validity of the requirements and the logic behind their selection. Validation is thereby limited to the rationale and requirements part of inference and analysis methodology, as depicted in Figure 46.

	VERIFY BY INFERENCE		VERIFY DIRECTLY
	Requirements and Rationale	Components	Whole Item
ANALYSIS	X	X	
INSPECTION		X	X
TEST		X	X
DEMONSTRATION		X	X

Figure 46 Validation of Requirements Methodologies

In-process verification is also limited, by definition, to inference (if it was possible to validate the item directly you would be performing a form of qualification verification). It adds to validation, however, by considering the risk of developing the components, whether they are at an early design concept or beginning production. See Figure 47 for an illustration of available methodologies for in-process verification.

	VERIFY BY INFERENCE		VERIFY DIRECTLY
	Requirements and Rationale	Components	Whole Item
ANALYSIS	X	X	
INSPECTION		X	X
TEST		X	X
DEMONSTRATION		X	X

Figure 47 In-Process Verification Methodologies

Qualification verification may be performed using any of the methodologies, as illustrated in Figure 48. The capability may be verified as a whole or it may be verified by inference, particularly if it is expensive, impractical, or impossible to verify as a whole.

	VERIFY BY INFERENCE		VERIFY DIRECTLY
	Requirements and Rationale	Components	Whole Item
ANALYSIS	X	X	
INSPECTION		X	X
TEST		X	X
DEMONSTRATION		X	X

Figure 48 Qualification Verification Methodologies

Operational verification is a form of demonstration that takes place in an operational environment over a period of time, and uses methodologies as depicted in Figure 49.

	VERIFY BY INFERENCE		VERIFY DIRECTLY
	Requirements and Rationale	Components	Whole Item
ANALYSIS	X	X	
INSPECTION		X	X
TEST		X	X
DEMONSTRATION		X	X

Figure 49 Operational Verification Methodologies

Once methodologies have been reduced to those that serve the purpose of the verification, tradeoffs should be performed among the available methods to select the optimal one. Such tradeoffs should consider many factors. One factor is the specific method by which a given diagnostic requirement is implemented. A requirement implemented by embedded techniques or support equipment may be verified by testing, while an implementation in technical orders may necessitate inspection. Another factor is the criticality of the need for diagnostic information. A critical need for diagnostic information may dictate an exhaustive verification dedicated to the diagnostics, whereas a less critical need may be verified in conjunction with other features. If implementation of a specific performance requirement also requires diagnostic information to make a decision, the test or demonstration of the performance requirement may also verify the diagnostic requirement. Additional factors are as follows:

Costs
Risk
Reliability
Accuracy

Additionally, diagnostic capability can be verified either by itself, along with the performance features of an item, as part of an overall test plan that combines the diagnostic capability of many items, or in a combination of these ways. A group of requirements (diagnostic, performance, safety, etc) can often be verified in the same time frame, using the same hardware and software for the selected verification method, thereby reducing the cost of verifying each individual requirement.

90.3.4 Verification methods by acquisition phase. Particular verification methods tend to be most useful in certain phases. At the system design level, the following acquisition phase selections are typical for performance requirements:

Concept Development	Analysis
Dem/Val	Analysis of low-risk items and functions, test, or demonstration of high risk-items and functions
FSD	Test
OT&E	Demonstration

Figure 50 indicates which diagnostic methods (analysis, inspection, test, or demonstration) are typically suited to the various acquisition phases and design levels.

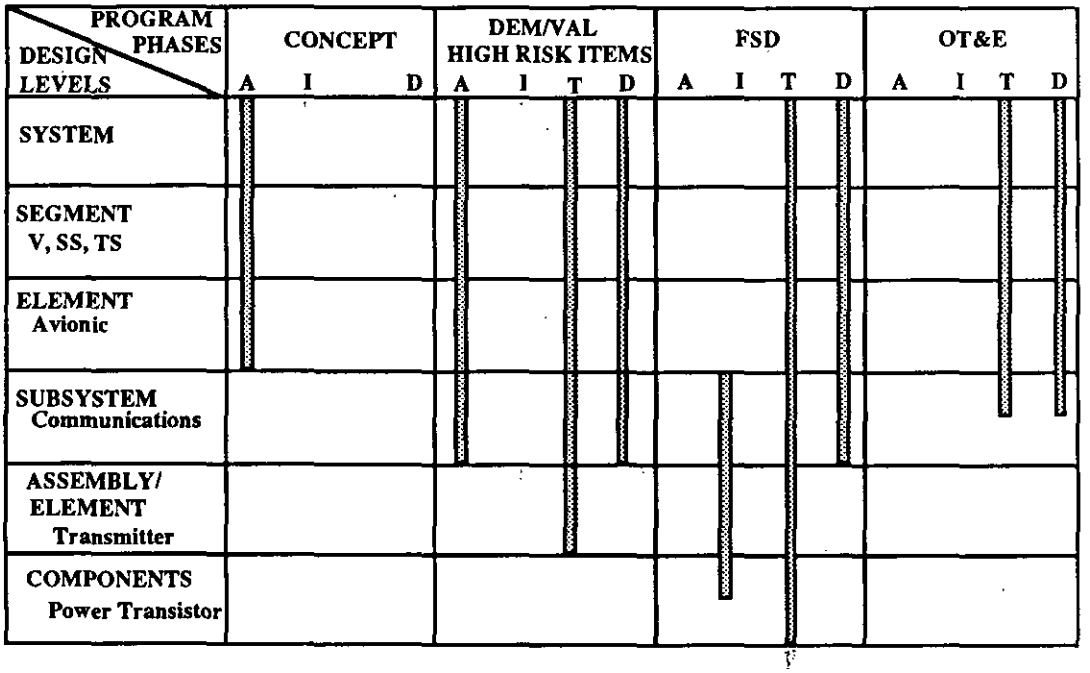


Figure 50 Verification Method is Dependent on Program Phase and Design Level

90.4 DIAGNOSTIC MIX ELEMENTS. There are a variety of diagnostic elements from which to select when deciding how to implement diagnostic requirements (in other words, there are many ways in which diagnostic detection, isolation, and reporting may be accomplished). Some examples are:

Built in Test (BIT)
Technical Orders (TOs)
Support equipment, interfaces and Test Program Sets (TPSs)
Trained operational and maintenance personnel

There are different ways to organize these elements. This section will discuss two of them, a simple structure that defines the elements in the same structure as the AFGS-87256 requirements and a matrix that relates these elements to on- and off-board implementations.

90.4.1 Diagnostic elements. The diagnostic elements fall under three categories, embedded, support equipment, and manual. These categories are useful because they parallel the segment elements (vehicle, support, and training) addressed in system design. Within each category, there are different ways to accomplish that type of diagnostics. See Table 22 for a listing of the major diagnostic elements under this structure and AFGS-87256 for discussions of these elements.

Table 22 Diagnostic Elements

EMBEDDED	SUPPORT EQUIPMENT	MANUAL
BIT Continuous monitoring Initiated Go/No-go checks Interfaces	Automatic testing Semiautomatic testing Manual testing BITE Interfaces TPSs	Training Simulators Formal On-the-job TOs Paper Automated Information systems

90.4.2 Diagnostic elements on and off-board. In deciding which elements should be used for a given application it is helpful to consider whether the diagnostic information will be required to support on or off-board actions. Onboard actions, such as an inflight mission commitment decision, must be supported by onboard diagnostic elements. An off-board action, such as I or D maintenance level repairs, may use both off-board and onboard diagnostic elements. An example would be depot level fault isolation that can use BIT to gather environmental data for recreating the failure circumstances and semiautomatic testers to recreate this environment for fault isolation. See Table 23 for how the diagnostic element categories and specific elements relate to onboard or off-board applications.

Table 23 Diagnostic Elements On and Off Board

DIAGNOSTIC ELEMENTS	ONBOARD	OFF-BOARD
EMBEDDED	BIT Interfaces	
SUPPORT EQUIPMENT	BITE Interfaces	Automated Semiautomated Manual TPS
MANUAL	Trained personnel TOs Information systems	Trained personnel TOs Information systems

To select particular elements for implementation of a given diagnostic requirement, determine from Table 22 which types or combinations of elements are appropriate for the decision/event being supported and conduct tradeoffs between available alternatives. Some items to consider in conducting these tradeoffs are as follows.

Costs
Risk
Reliability
Accuracy
Penalties (space, weight, power, increased complexity, etc.)
Constraints (mobility restrictions, mean or max times to diagnose, etc.)
Availability of useful capability designed in for other reasons

90.5 ID PROCESS INTERFACES. ID is an integral part of the system engineering process, in accordance with MIL-STD-499. It has a multitude of interfaces that relate to policy and content, engineering and logistics disciplines, individual design techniques and diagnostic elements, and Modular Automatic Test Equipment (MATE) Programs. These interfaces are

essential for implementing the integrated diagnostic process. This section provides an overview of these interfaces.

90.5.1 Understanding the process. Appendix I contains a Roadmap that depicts the flow of diagnostic activities by acquisition phase. This Roadmap is necessarily complex. A simplified version is provided in Figure 51, to serve as a basis for relating to other disciplines.

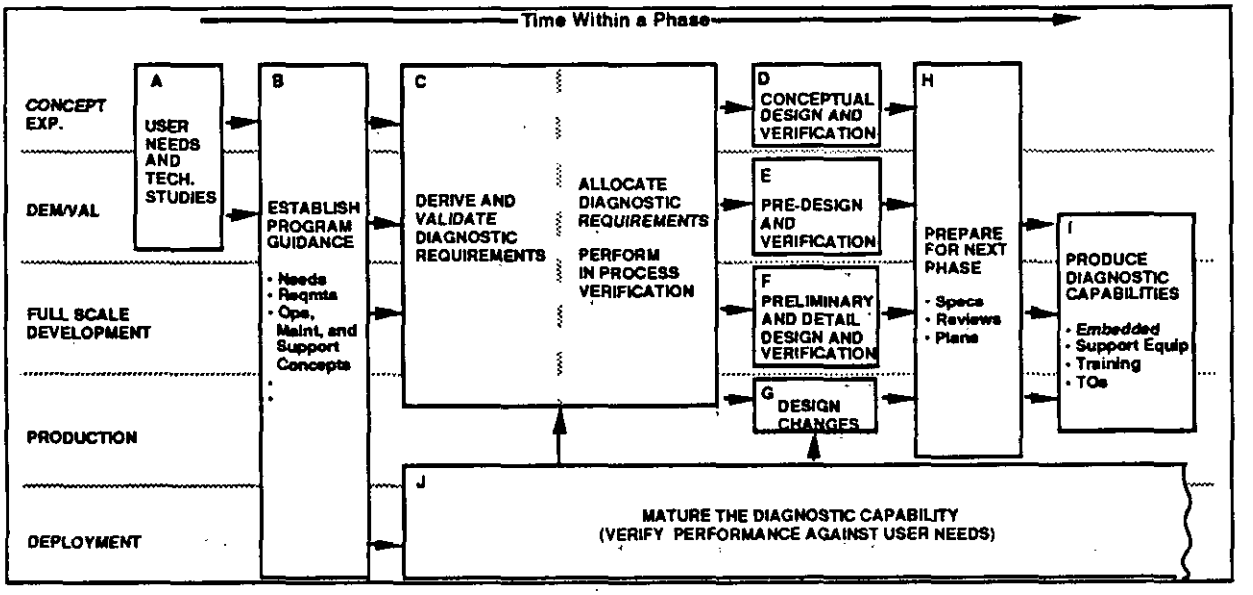


Figure 51 Simplified ID Activities by Phase (Roadmap)

Moving from left to right, Figure 51 starts in the Concept Exploration or Dem/Val Phases with user needs and technology studies that generate a need to acquire a new weapon system. These needs lead to program guidance, such as SORDs, DSRDs, RFPs, and SOWs, that begin an acquisition phase. The "establish program guidance block" extends to all phases because each phase has objectives to accomplish.

The next block deals with deriving and validating diagnostic requirements and then allocating them and performing in process verifications. See Appendix B for details. Derivation and allocation should take place in most phases although the emphasis may be on derivation in early phases and allocation in final phases. This block covers all but the deployment phase but may be performed even in this phase if the maturation plan feeds back the need to reassess earlier derivations or allocations.

Next, the level of design detail applicable to each phase must address the derived and allocated diagnostic requirements. Designers must ensure that they provide for obtaining the required diagnostic information as part of the overall capability of the item being designed. This is where diagnostic functional requirements are implemented as physical resource capabilities.

The "prepare for the next phase block" deals with conducting reviews, establishing specs, etc, to determine the goals for any follow-on phases. The diagnostic capability must be part of such activity.

The final block on the right addresses producing any hardware or software required in the acquisition phase, ranging from demonstration items to full rate production runs. This production should stress concurrent delivery of all components of the diagnostic capability.

The deployment phase differs from earlier ones in that it is concerned with evaluating the fielded performance of the produced items, to feed back any need for changes or modifications and to build a baseline of diagnostic information for future acquisitions.

90.5.2 Logistic support and engineering disciplines. There are many interfaces between diagnostics and logistic support and engineering disciplines. Figure 52 depicts the major interfaces that relate to the integration of these disciplines.

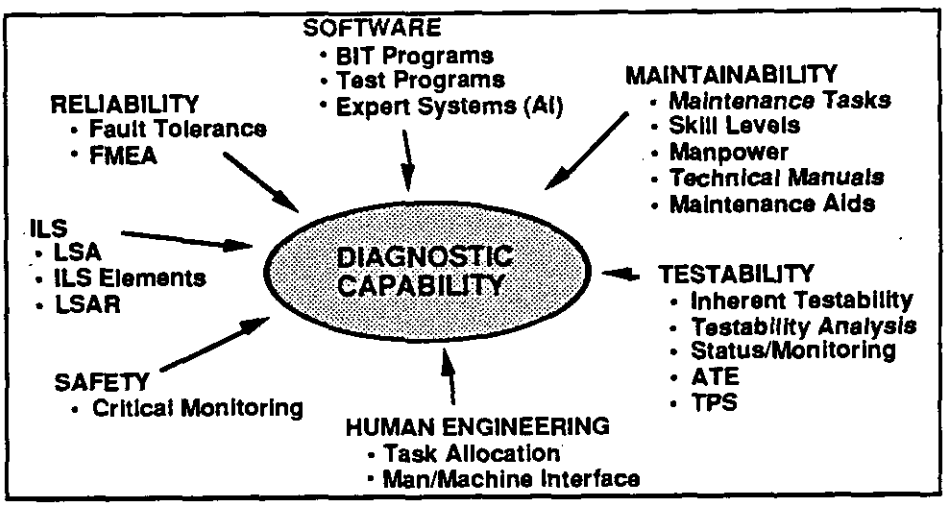


Figure 52 Integration of Disciplines

The following military standards and specifications support logistic support and engineering disciplines that interface with the ID process.

MIL-STD-1388-1	Logistic Support Analysis
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-470	Maintainability Program for Systems and Equipment
MIL-STD-2165	Testability Program for Systems and Equipment
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment, and Facilities
MIL-STD-882	System Safety Program Requirements
DOD-STD-2167	Defense System Software Development

Figure 53 relates programmatic documents to the simplified Roadmap in Figure 51. There are many interfaces between the ID process and the activities generated by these documents.

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	DIAGNOSTIC ACTIVITIES	PROGRAMMATIC STANDARDS: MIL-STD-1388 Log. Supt. Anal.	MIL-STD-785 Reliability	MIL-STD-470 Maintainability	MIL-STD-2165 Testability	MIL-H-46855 Human Engineering	MIL-STD-882 System Safety	DOD-STD-2167 Software
A	User Needs	X						
B	Program Guidance	X	X	X	X	X	X	X
C	Diag. Reqmts Deriv. & Alloc.	X	X	X	X	X	X	X
D	Conceptual Design & Verif.	X	X	X	X	X	X	X
E	Predesign and Verification	X	X	X	X	X	X	X
F	Prelim. & Detail Design & Verif.	X	X	X	X	X		X
G	Design Changes	X						
H	Pgm Monitoring & Control	X	X	X	X	X	X	X
I	Diagnostic Product	X			X			X
J	Maturation	X	X	X	X	X		X

Figure 53 Logistic Support and Engineering Discipline Interfaces

90.5.3 Design techniques and diagnostic elements. The following product or process military standards, handbooks, and guides relate to individual diagnostic elements.

MIL-STD-334(TM)	Displayed Messages for ATE
MIL-STD-415	Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for
MIL-STD-471	Maintainability Demonstration
MIL-STD-1379	Contract Training Programs
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities
MIL-STD-1519	Test Requirements Document, Preparation of
MIL-STD-1629	Procedures for Performing a Failure Mode, Effects, and Criticality Analysis
DOD-STD-1685(SH)	Comprehensive Standards for Technical Manuals (Metric)
MIL-STD-1752	Reading Level Requirements for Preparation of Technical Orders

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MIL-STD-2077	Test Program Sets, General Requirements for
DOD-STD-2121	Determination of Electronic Test Equipment Parameters
MIL-STD-2155(AS)	Failure Reporting Analysis and Corrective Action System
MIL-HDBK-59	DoD Computer-Aided Acquisition and Logistic Support (CALS) Program Implementation Guide
MIL-HDBK-300(H)	Technical Information File of Support Equipment
MIL-T-28800	Test Equipment for Use With Electrical and Electronic Equipment, General Specifications for
AFSCP 800-39	BIT Design Guide
PB82-123745	Sensor Handbook for Automated Test, Monitoring Diagnostic and Control Systems Applications to Military Vehicles and Machinery
(no numerical designation)	Testability Analysis Handbook (Source: NAVSEA 04 D5)
MIL-M-38784	Manuals, Technical: General Style and Format Requirements

Figure 54 depicts the relationships between the above documents and the individual diagnostic elements. Also depicted are relationships to the various design techniques applicable to diagnostics.

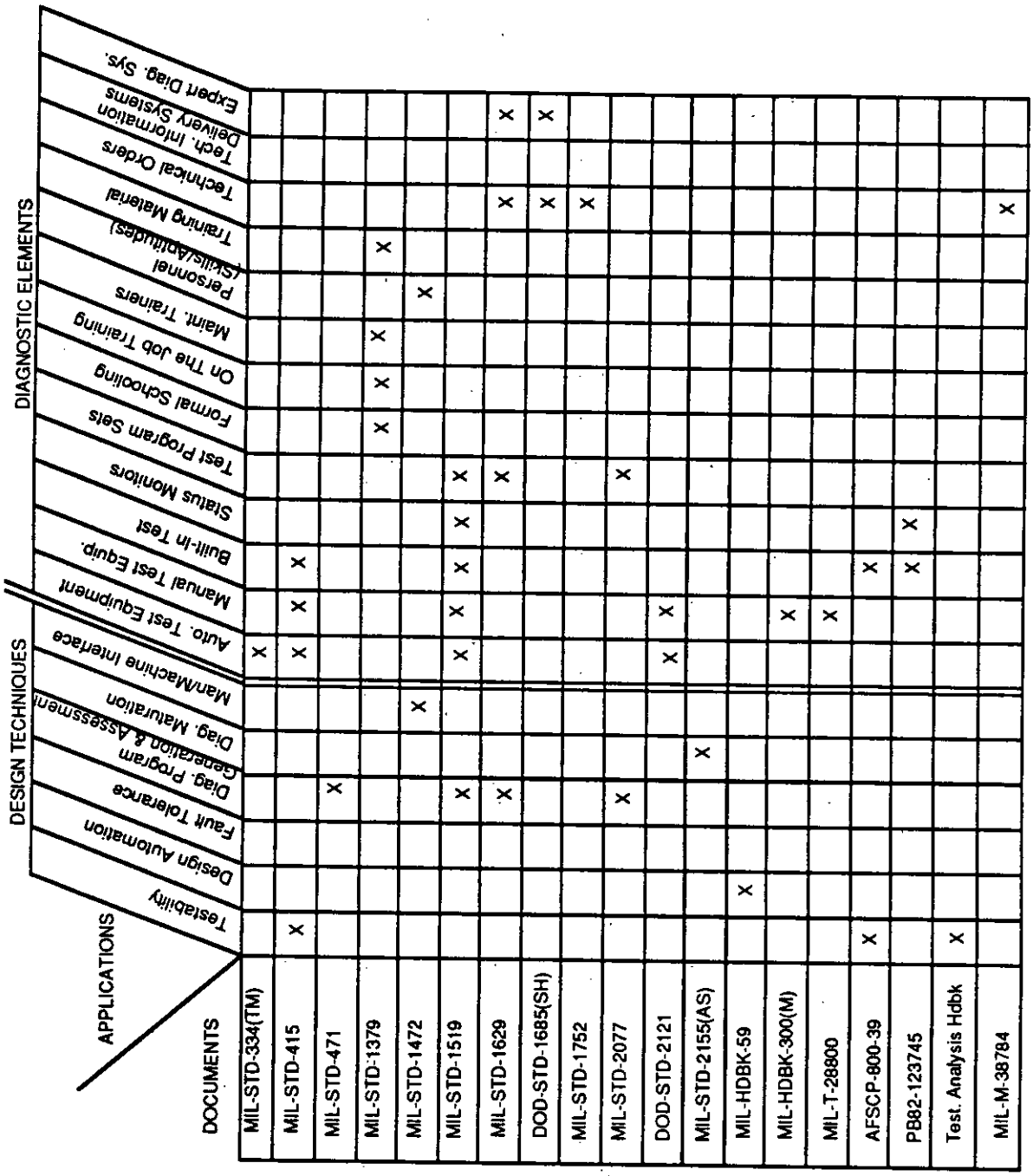

Figure 54 Diagnostic Product/Process-Type Interfaces

90.5.4 Policy and control interfaces. Throughout Appendix A, a number of directives, instructions, and regulations cite policy and provide controls that are applicable to the ID process. The major ones are as follows.

AFLC/AFSC-P-800-34	Acquisition Logistics Management
AFP-57-9	Defining Logistics Requirements in Statement of Need
AFR-57-1	Operational Needs, Requirements, and Concepts

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AFR-80-14	Research and Development Test and Evaluation
AFR-800-2	Acquisition Program Management
AFR-800-8	ILS Program
AFR-800-12	Acquisition of Support Equipment
AFSC-P-800-3	A Guide for Program Management
AFSC/AFLC-R-800-23	Policy for Modular Automatic Test Equipment
DODD 5000.3	Test and Evaluation
DODD 5000.3-M-1	Test and Evaluation Master Plan (TEMP)
DODD 5000.53	MPTS in the Defense System Acquisition Process
DODD INST 5000.2	Defense Acquisition Program Procedures

Figure 55 relates the above documents to the Figure 66 simplified ID process.

REGULATIONS AND DIRECTIVES	INTERFACE DOCUMENTS	DIAGNOSTIC ACTIVITIES: A. User Needs	B. Program Guidance	C. Diag Reqmts Derivation & Allocation	D. Conceptual Desig & Verification	E. Predesign & Verification	F. Prelim & Detail Design & Verif	G. Design Changes	H. Program Monitoring & Control	I. Diagnostic Product	J. Maturation
AFLC/AFSC-P-800-34	N/A	X	X						X		X
AFP-57-9	SON	X									
AFR-57-1	SON, SORD, DSRD	X	X								
AFR-80-14	Test & Eval Master Plan		X						X		X
AFR-800-2	Program Mgmt Plan		X								
AFR-800-8	ILS Plan		X						X		X
AFR-800-12	Supt Equip Master Plan		X						X		
AFSC-P-800-3	Program Mgmt Plan		X						X		X
AFSC/AFLC-R-800-23	MATE Handbooks		X						X		
DODD 5000.3	Test & Eval Master Plan		X						X		X
DODD 5000.3-M-1	Test & Eval Master Plan								X		
DODD 5000.53	Manpower Est Report		X	X							
DODINSTR 5000.2	MNS, SCP/DCP	X							X		X

Figure 55 Policy and Control Interfaces

90.5.5 Modular Automatic Test Equipment (MATE) Program interfaces. The Air Force MATE Program has major interfaces with ID. MATE has a Roadmap and an acquisition process parallel to and integral to acquiring a weapon system's diagnostic capability. MATE requirements are derived through the ID process, requiring a close relationship between the two processes. The major MATE interface tasks (MATE Acquisition Handbook, Volume II) are as follows.

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TASK NO.	TASK TITLE
201	Develop Automatic Testing Segment of Program Management Plan
202	Generate Automatic Testing Inputs to RFP for Conducting Conceptual Phase Efforts
204	Assess AT System Engineering Results in Preparation for SRR
205	Participate in System Requirements Review
206	Generate AT Inputs for Required Validation Phase Documents
301	Provide AT Inputs to Appropriate SON Format
302	Develop AT Segment of PMP for Validation Phase Program Start
304	Generate AT Inputs for Validation Phase RFP
307	Assess AT System Engineering Results in Preparation for SDR
308	Develop AT Requirements for TEMP
309	Participate in System Design review
310	Generate AT Inputs for Required FSD Phase Documents
402	Develop AT Segments of PMP for FSD Start
403	Update AT Segment of Program Management Plan for Continuing Programs
404	Develop/Update AT Inputs to FSD RFP
405	Participate in Prime System Preliminary Design Review(s)
406	Participate in Prime System Critical Design Review(s)
408	Participate in Weapon System FCA
409	Participate in Maintainability Demonstration and OT&E
501 - 506	ATS Acquisition Process
601 - 620	ATE Development
651 - 656	TPS Development
703	ATE Site Activation and Operation
704	Update ATE Program Data
705	Plan for ATS Organic Support
801	ATE Modification Procedures
802	TPS Modification Procedures

Figure 56 depicts the interfaces between the above MATE Tasks and the ID Process.

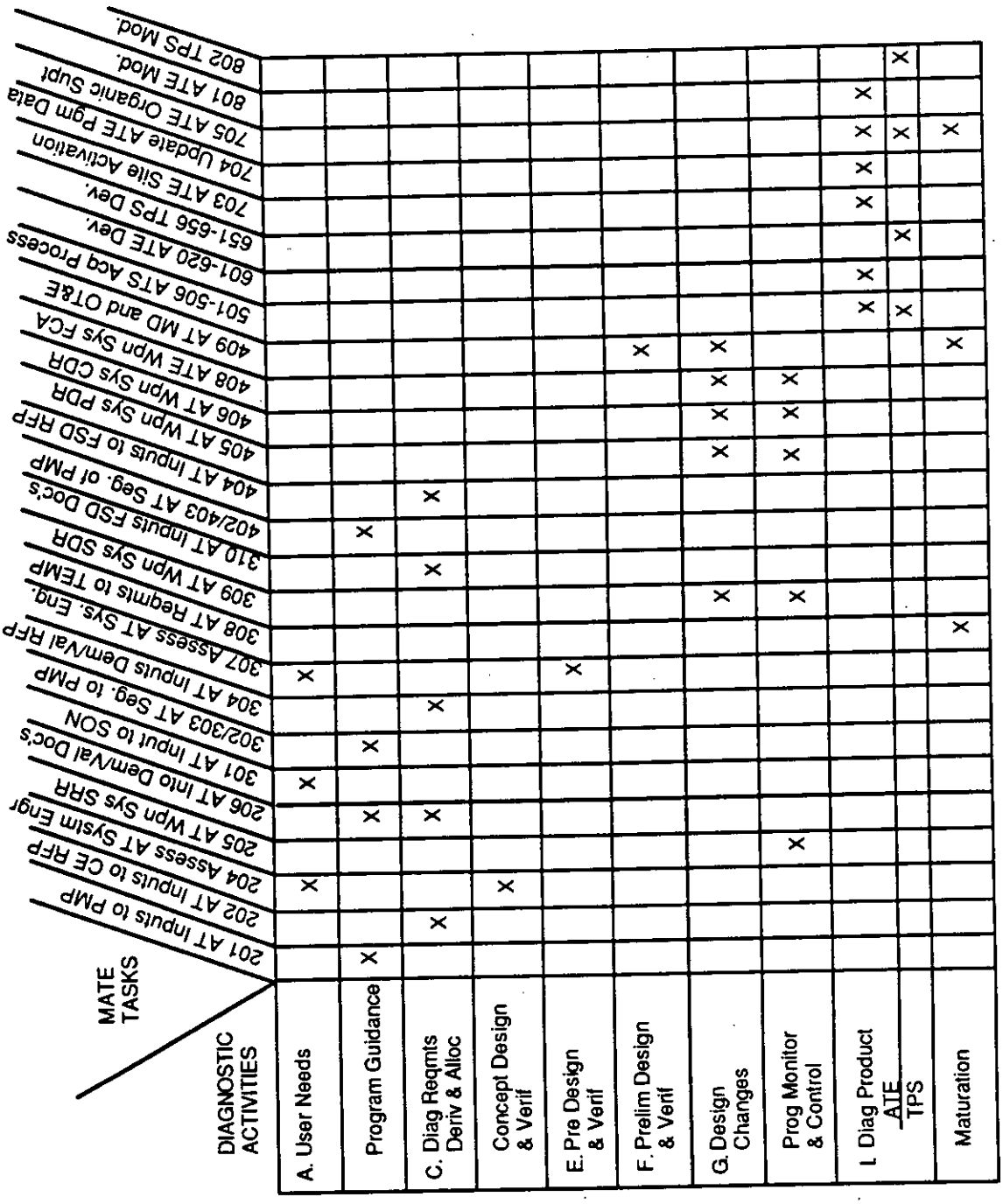

Figure 56 MATE/ID Process Interfaces

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APPENDIX I

100. ID ROADMAP

100.1 SCOPE. This appendix covers programmatic diagnostic activities for all acquisition phases.

100.1.1 PURPOSE. This appendix features a roadmap that depicts the flow of integrated diagnostics activities by acquisition phase. It is intended to allow both government and contractor representatives to enter a given phase and track the general flow of activities or isolate a specific activity. Each activity on the roadmap is numbered for ready reference to corresponding requirements and verifications in Section 3 and Appendix A.

100.1.2 APPLICATION. This appendix may be used for any ASD weapon system in any acquisition phase. Use only those activities that are applicable to the specific program.

100.2 APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

100.3 ROADMAP DEPICTION

100.3.1 Roadmap characteristics. The Roadmap includes the following:

1. The various phases of a weapon system life cycle.
2. Aspects of maintenance diagnostics incorporated into the weapon system life cycle.
3. Pieces of the maintenance diagnostics system.
4. The general time sequencing of the various maintenance diagnostic system definition, design, and test tasks.
5. When tradeoffs will be made, when tradeoffs will be updated, and how the various pieces tie together.
6. How maintenance diagnostics design trades are integrated as part of the system/subsystem design trades.
7. The tying together of the various requirements for maintenance diagnostics (e.g., LSA and FMEA).
8. The interrelationship of integrated diagnostics with reliability, maintainability, human engineering, testability, logistics, training, and quality assurance.
9. Reference to the ID Program Plan at the appropriate times.

100.3.2 Roadmap structure. The Roadmap is structured to provide the following information, as illustrated in Figure 57.

1. Activity number. Each activity shown in the roadmap is numbered with the same section number that is used in the main body, and in Appendix A, so it may be readily referenced in all areas. The numbering scheme reflects the organization of requirements by life cycle phases, as shown below.

Section No.	Subject
3.1	Development
3.1.1	Operational Requirements
3.1.2	Concept Exploration
3.1.3	Demonstration and Validation
3.1.4	Full-Scale Development
3.2	Production
3.3	Deployment

2. Activity Box. A concise description of the activity that must be performed and translated into a requirement.

3. Input. Preceding activities or events that are necessary to accomplish or initiate the activity.

4. Output. The results of accomplishing the activity, and subsequent activity(s) that must be performed.

5. Road signs. Shaded boxes with rounded corners that are placed near certain activity boxes to alert the user to requirements and interrelationships between that diagnostic activity and relevant engineering specialties."

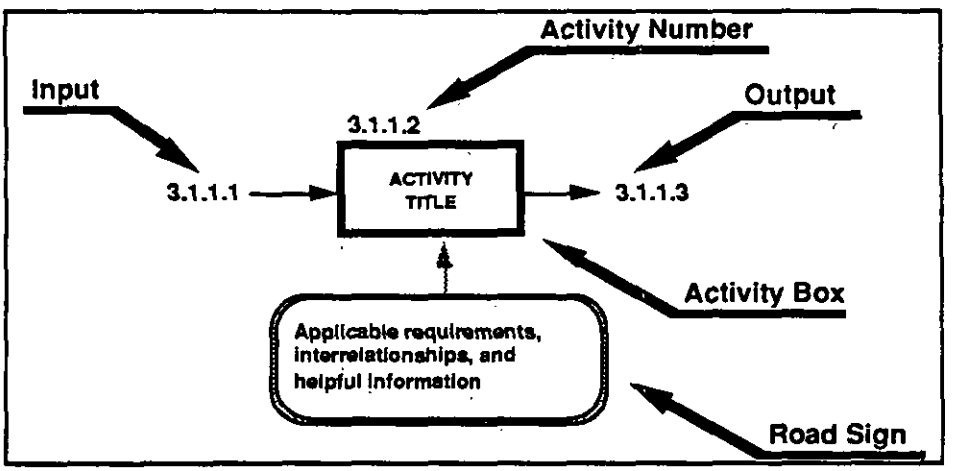
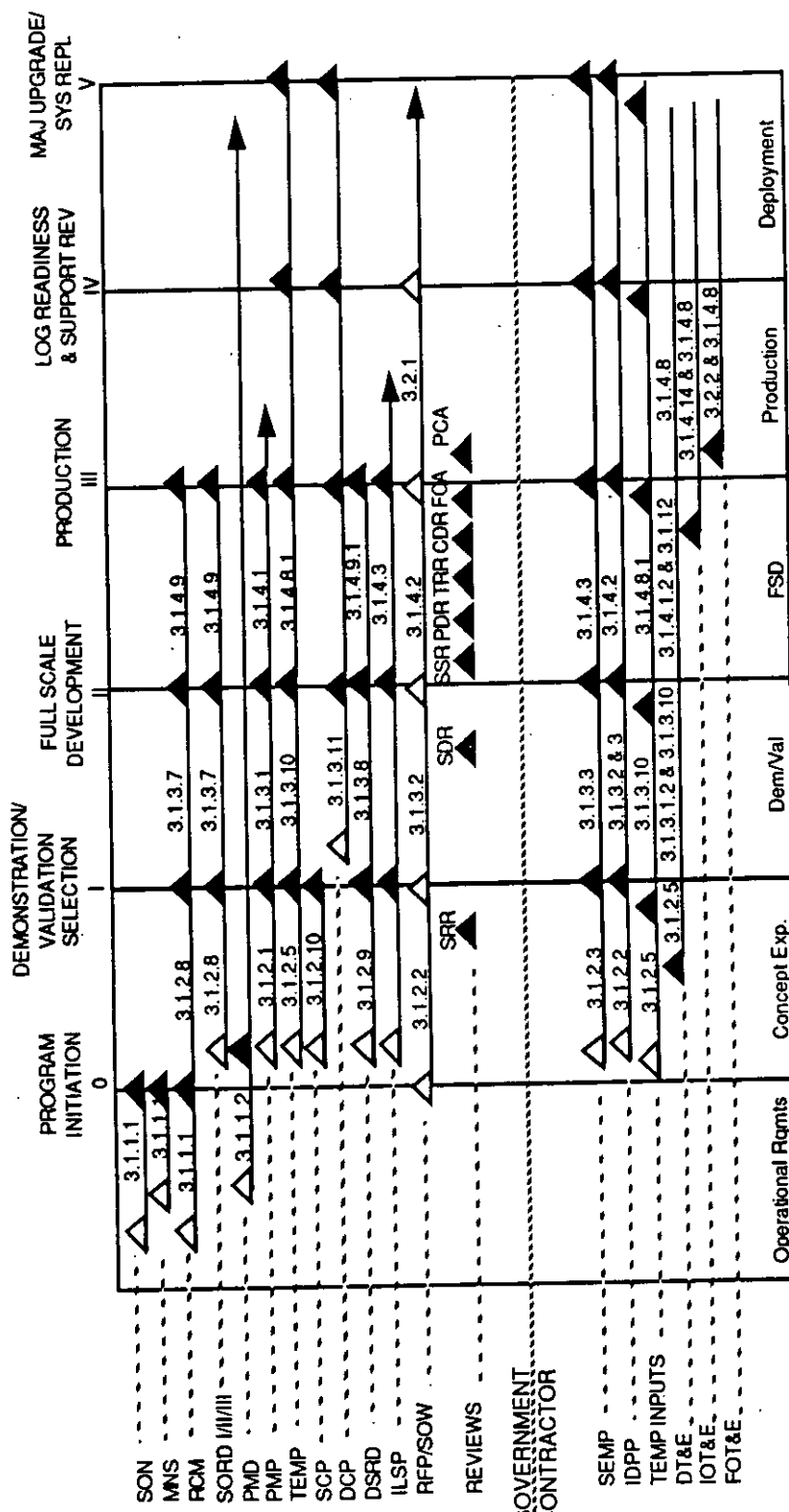


Figure 57 Roadmap Activity Symbology

100.3.3 Roadmap figures. See Figures 59 through 80 on the following pages.



This figure indicates the relevance of acquisition documents to the acquisition process life-cycle phases. Numbers on the figure refer to requirements that discuss these documents in the indicated phases.

For programs that do not perform some phases, refer to the requirements for the skipped phases to be sure critical documentation is performed, or its absence is compensated for.

This figure is a common reference for the Roadmap depictions that follow. It should be reviewed when suggested by Roadmap entries.

Figure 58 Phase Entry Reference

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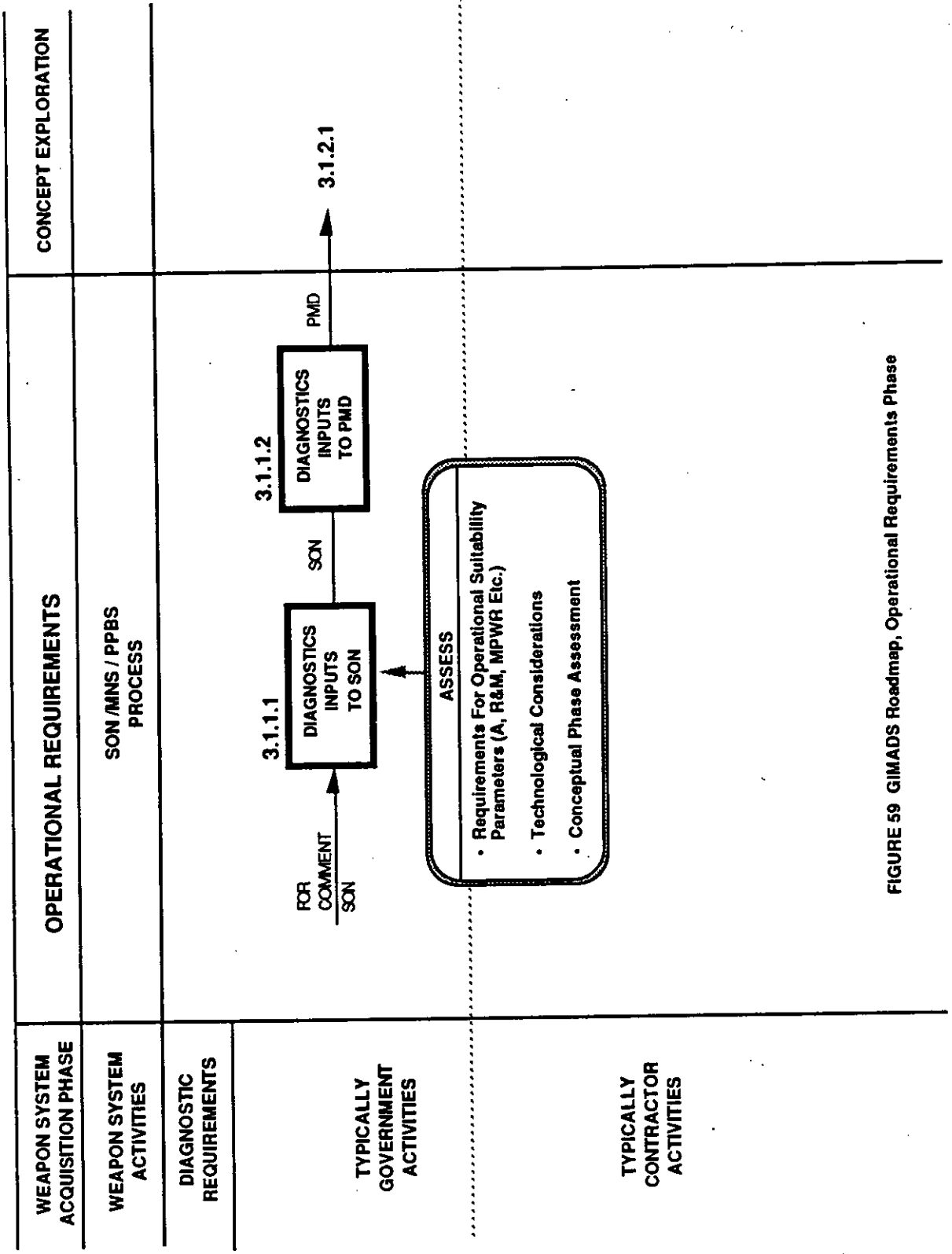

FIGURE 59 GIMADS Roadmap, Operational Requirements Phase

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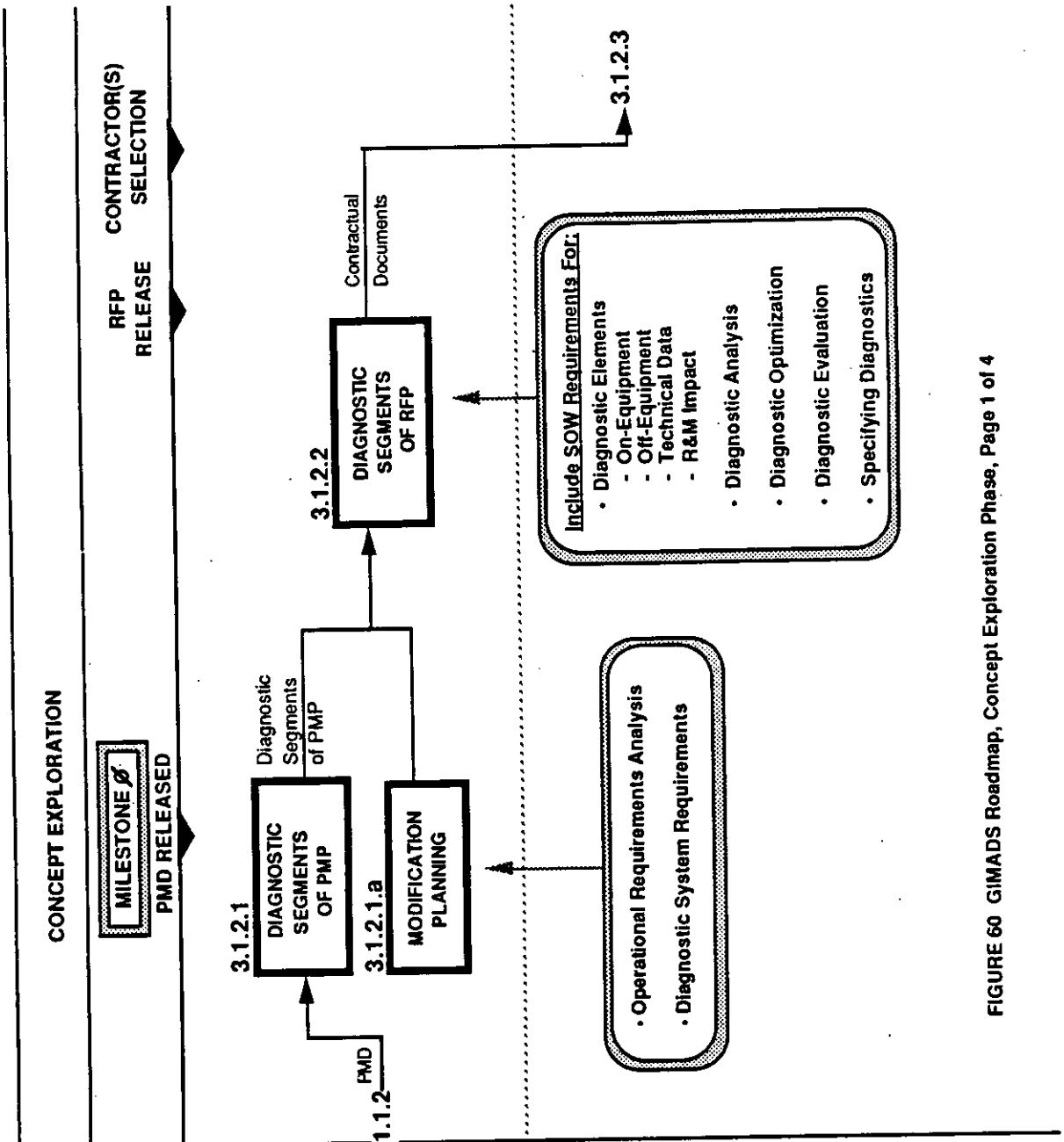

FIGURE 60 GIMADS Roadmap, Concept Exploration Phase, Page 1 of 4

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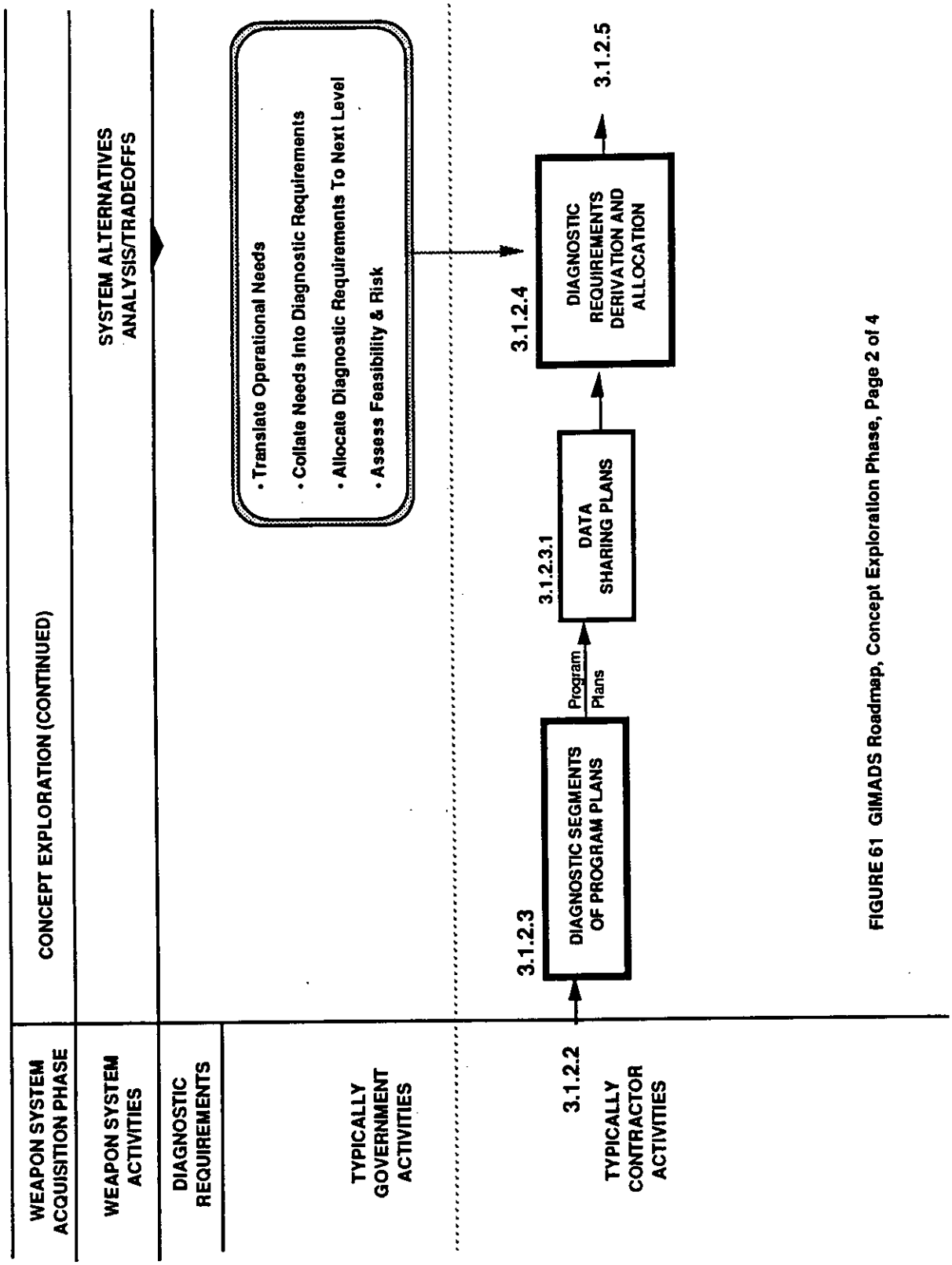

FIGURE 61 GIMADS Roadmap, Concept Exploration Phase, Page 2 of 4

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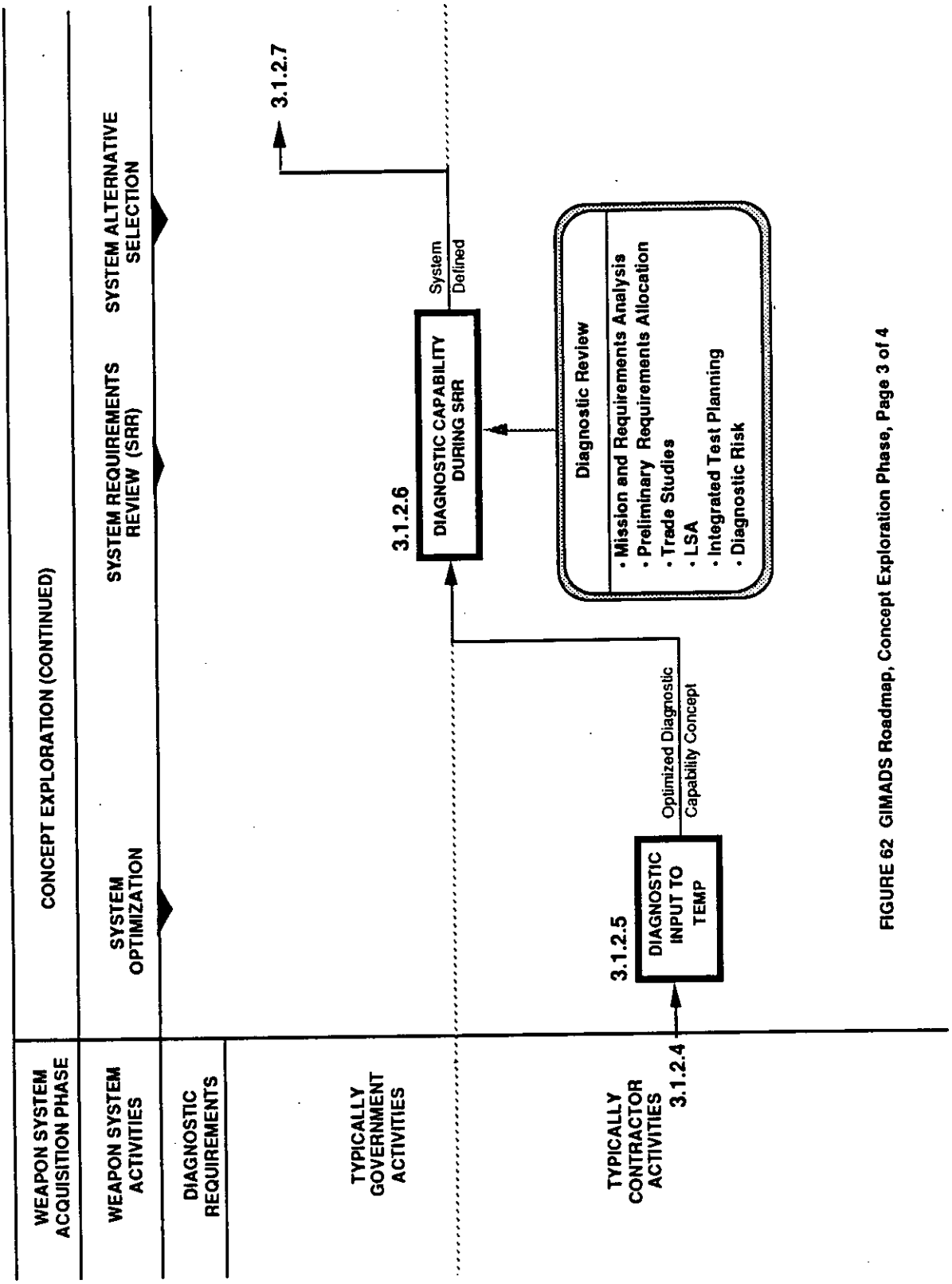

FIGURE 62 GIMADS Roadmap, Concept Exploration Phase, Page 3 of 4

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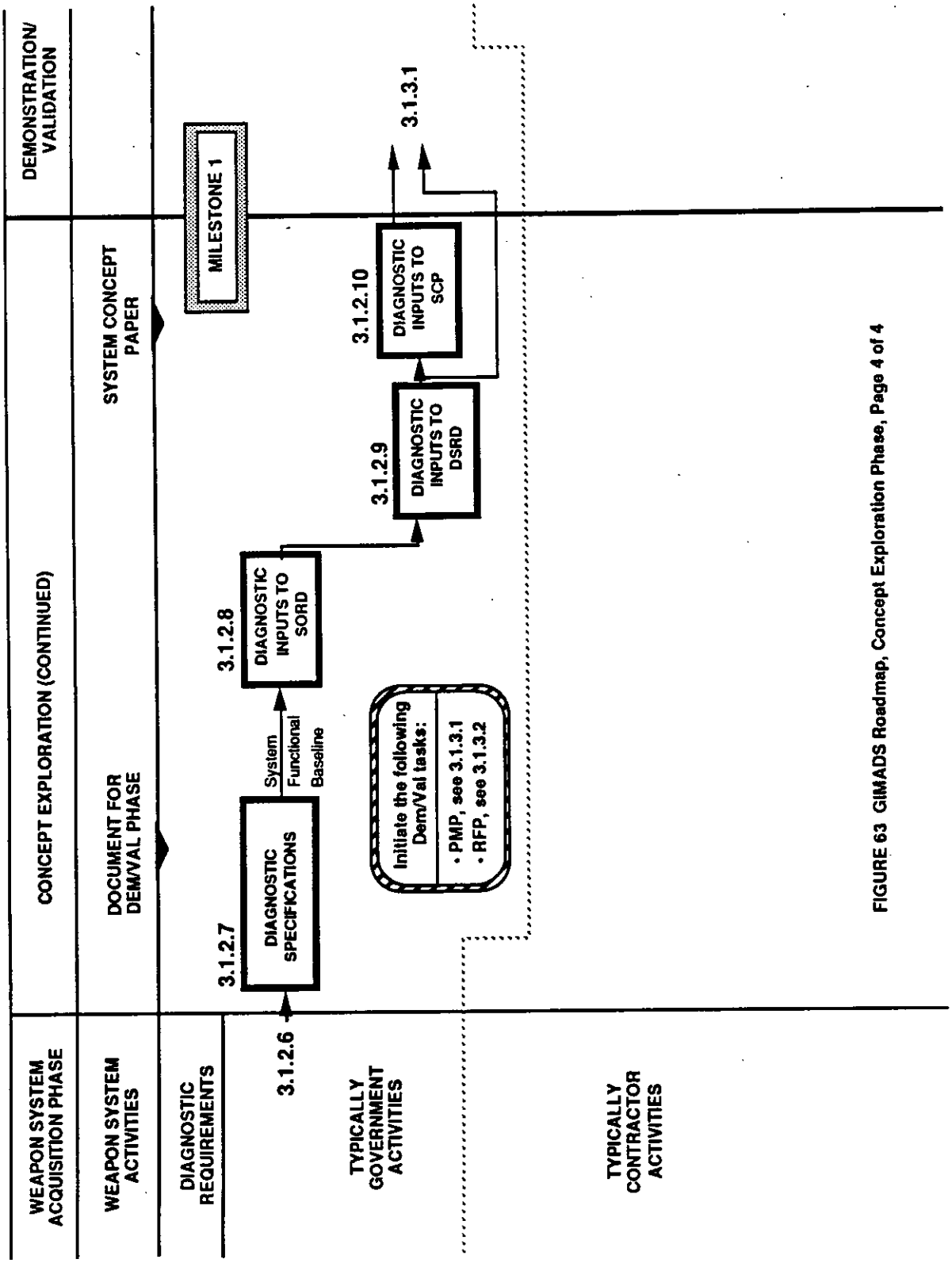

FIGURE 63 GIMADS Roadmap, Concept Exploration Phase, Page 4 of 4

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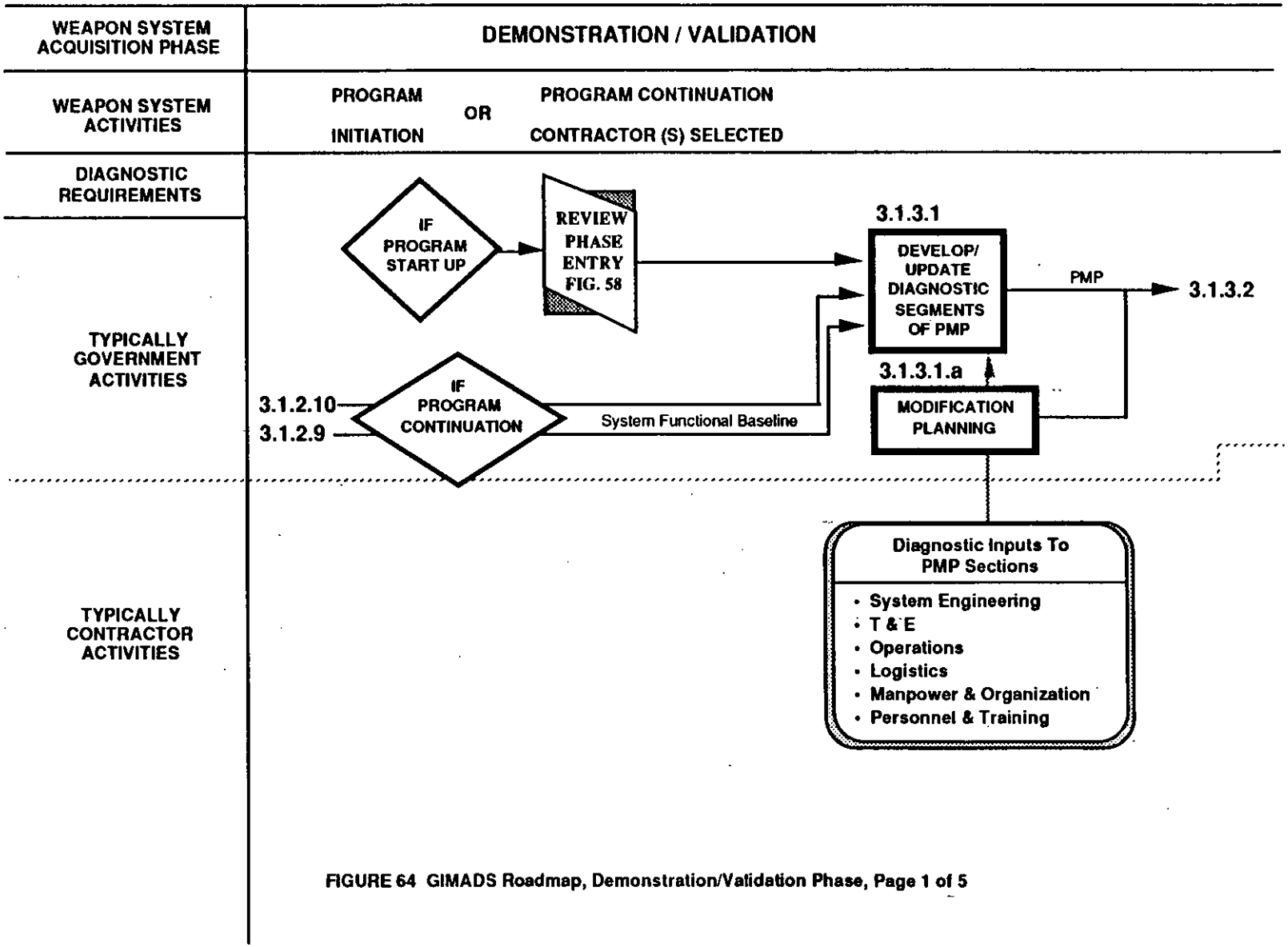

FIGURE 64 GIMADS Roadmap, Demonstration/Validation Phase, Page 1 of 5

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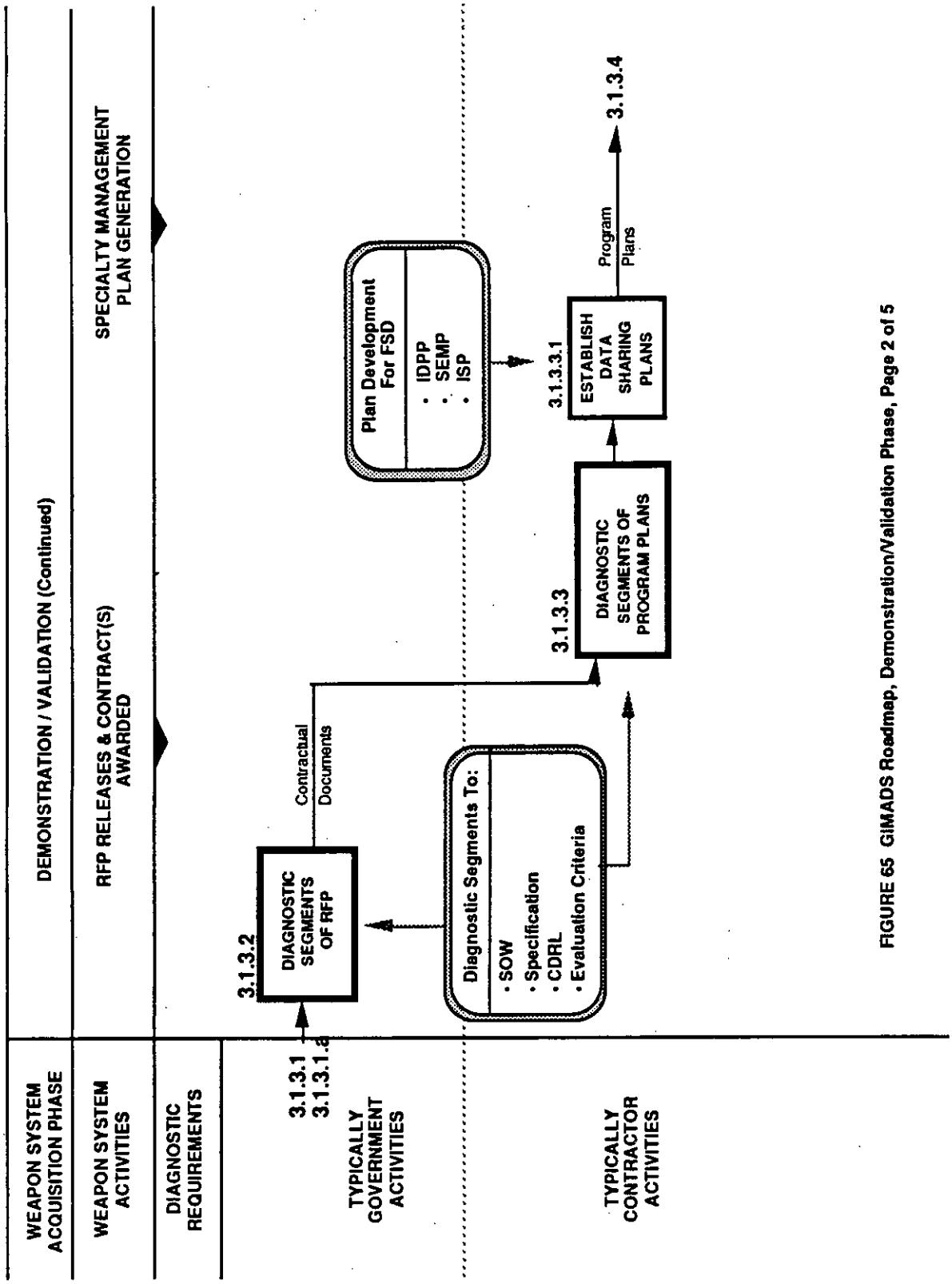

FIGURE 65 GIMADS Roadmap, Demonstration/Validation Phase, Page 2 of 5

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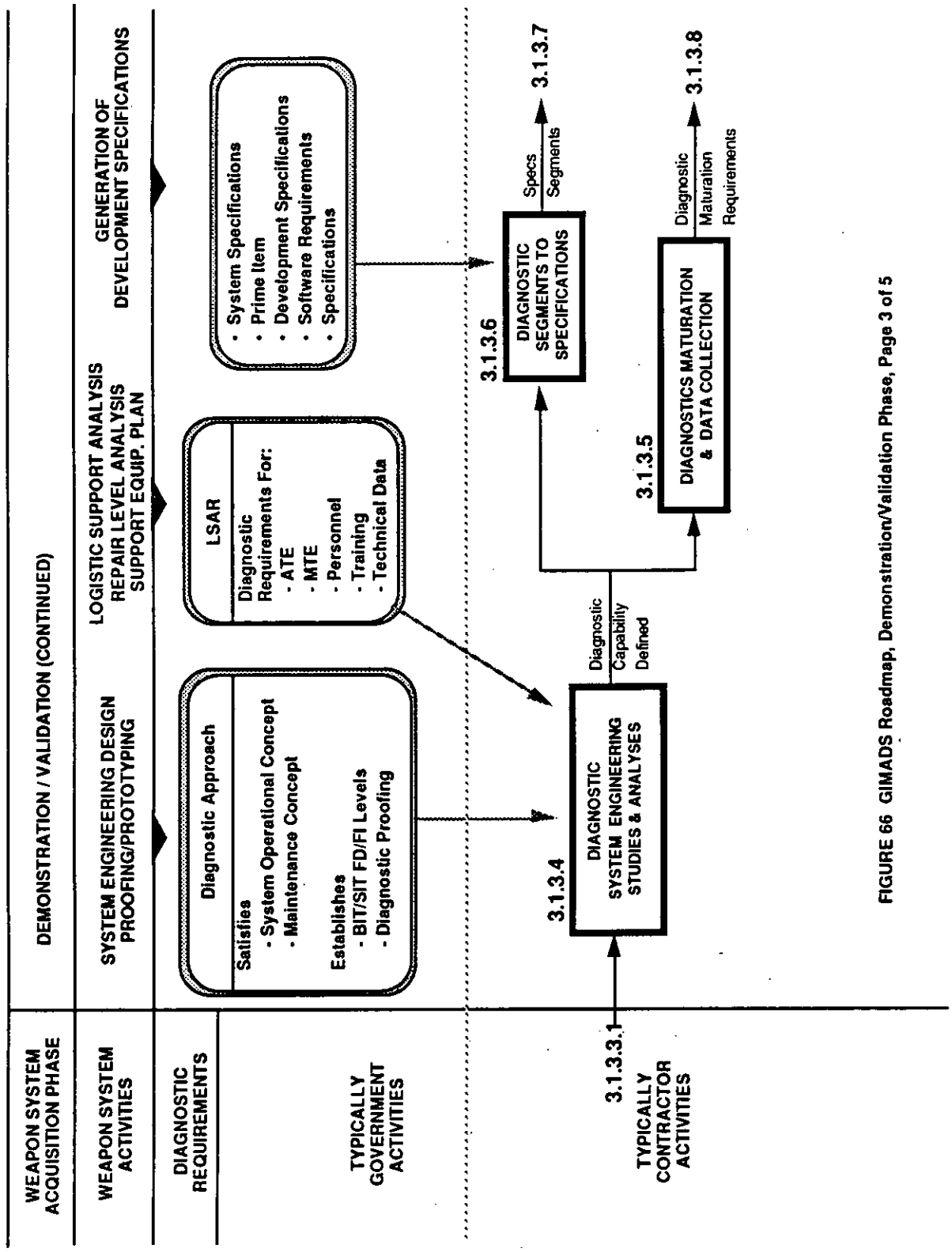

FIGURE 66 GIMADS Roadmap, Demonstration/Validation Phase, Page 3 of 5

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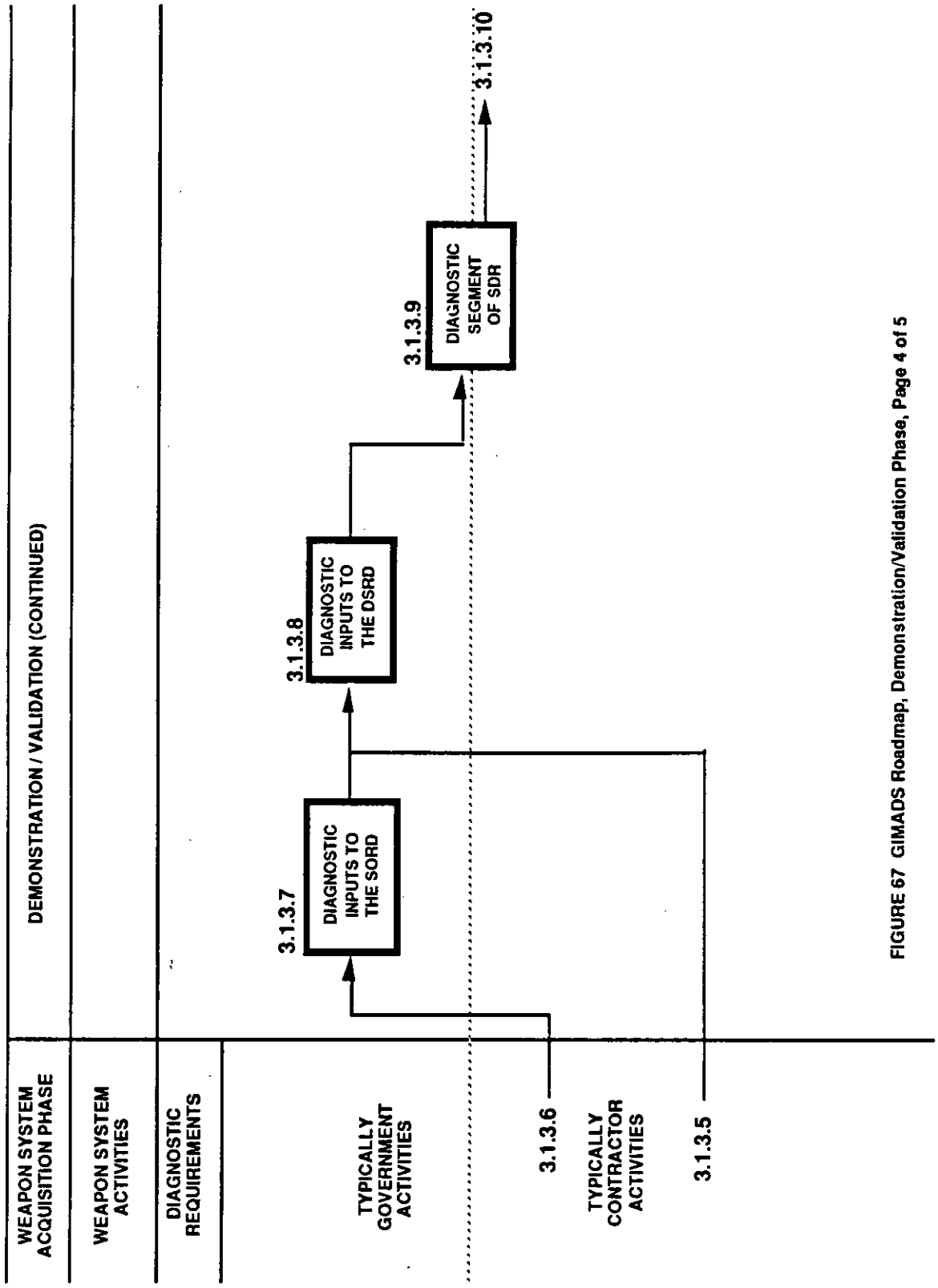

FIGURE 67 GIMADS Roadmap, Demonstration/Validation Phase, Page 4 of 5

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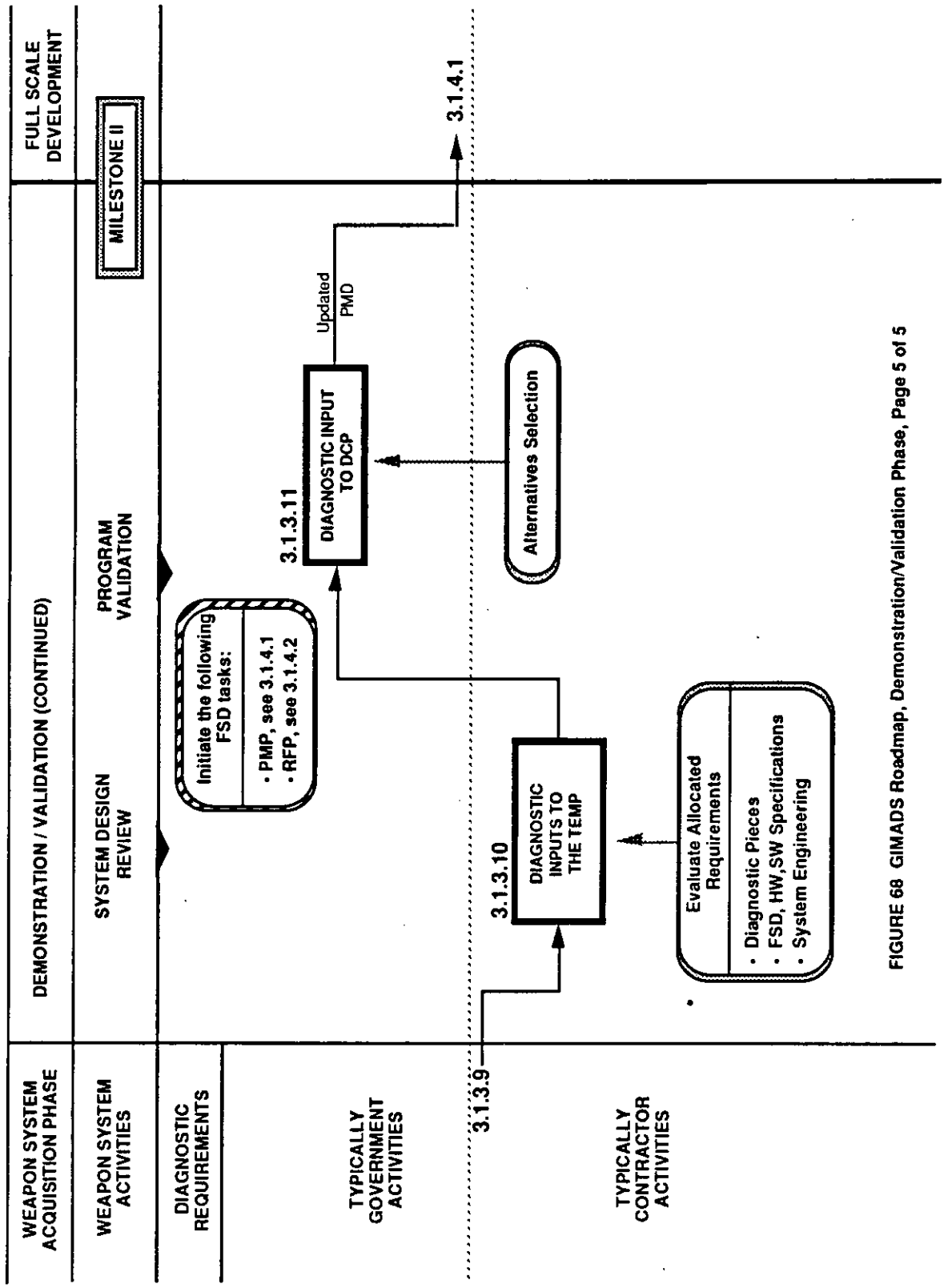

FIGURE 68 GIMADS Roadmap, Demonstration/Validation Phase, Page 5 of 5

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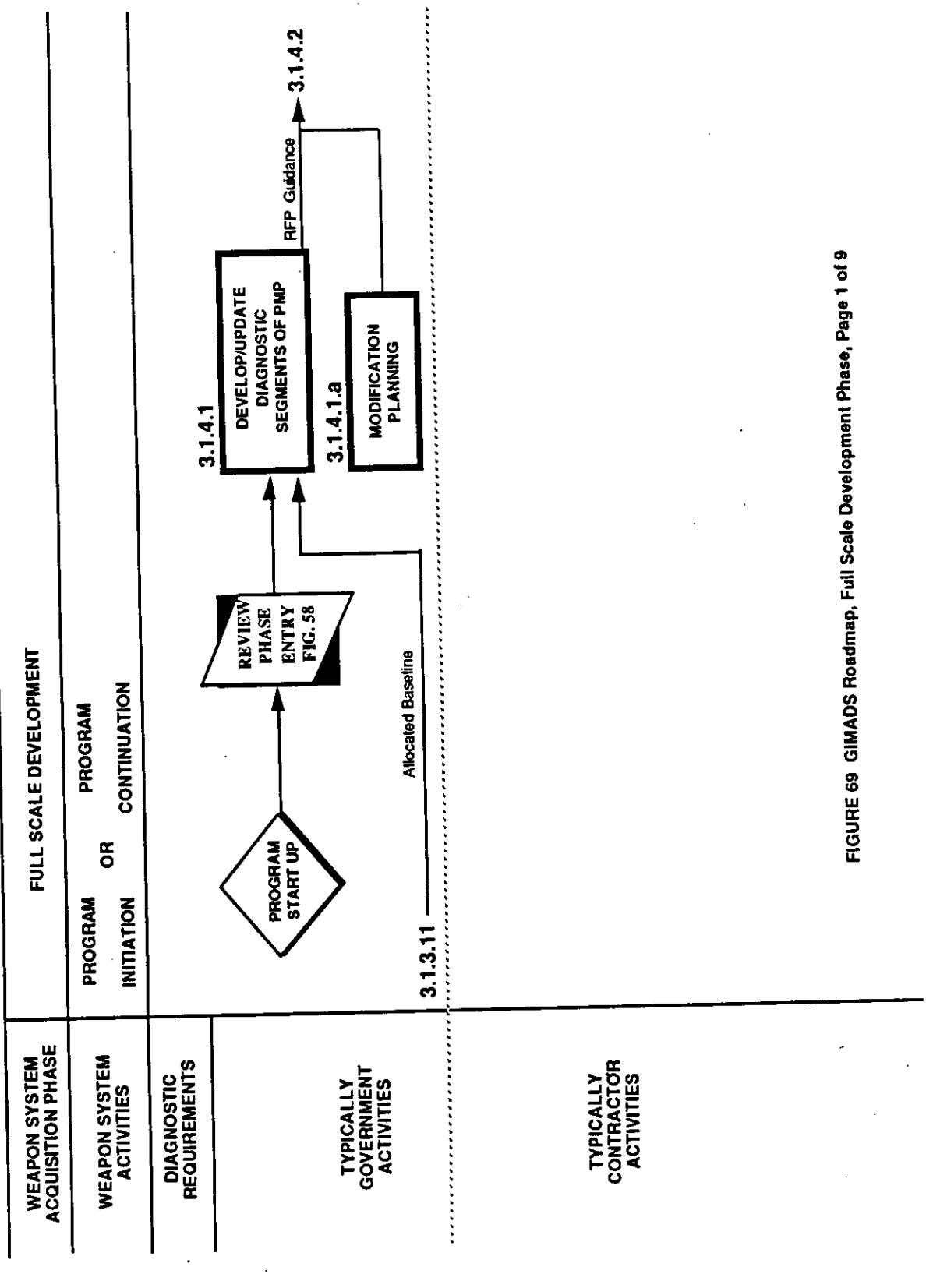

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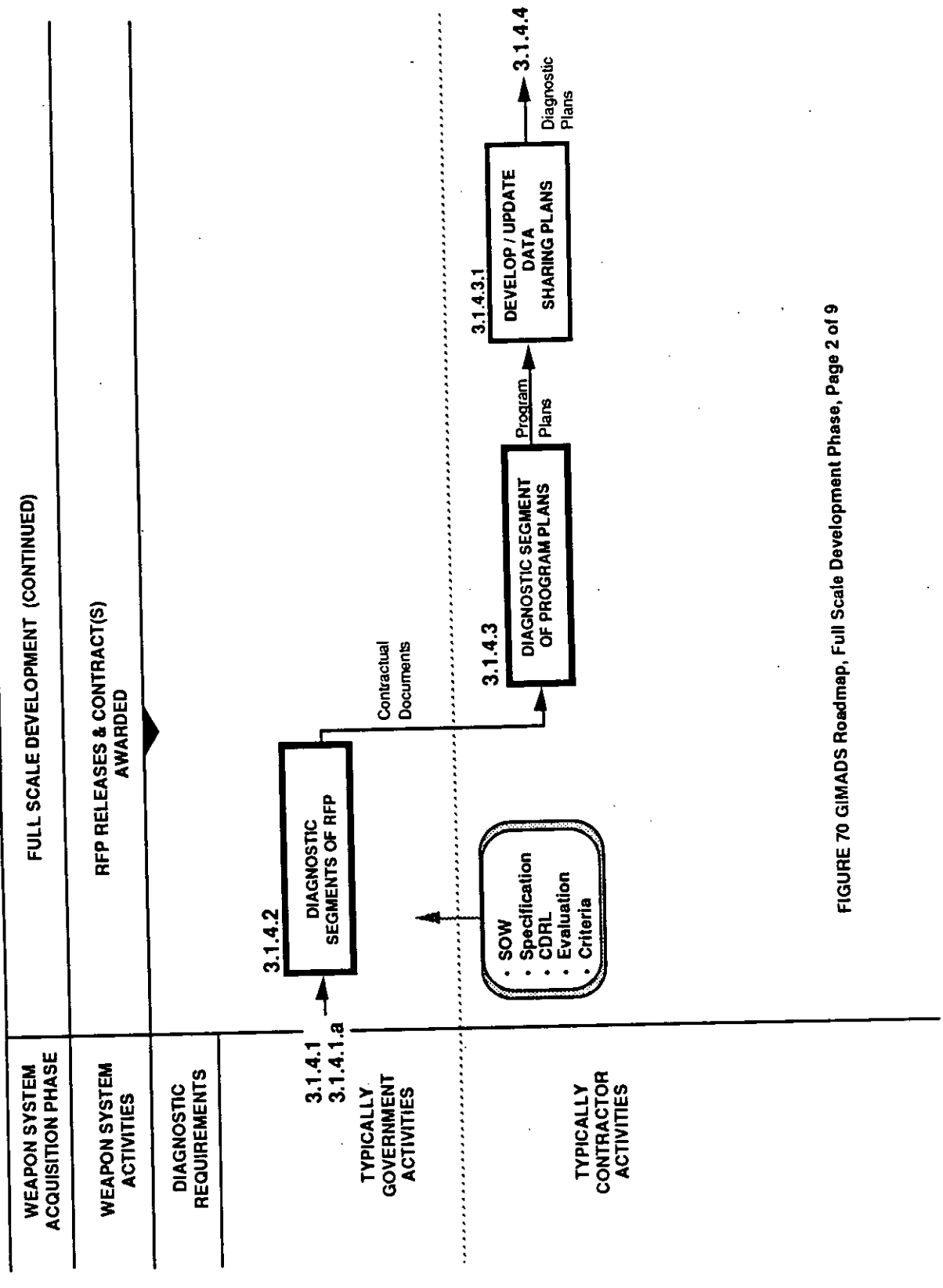

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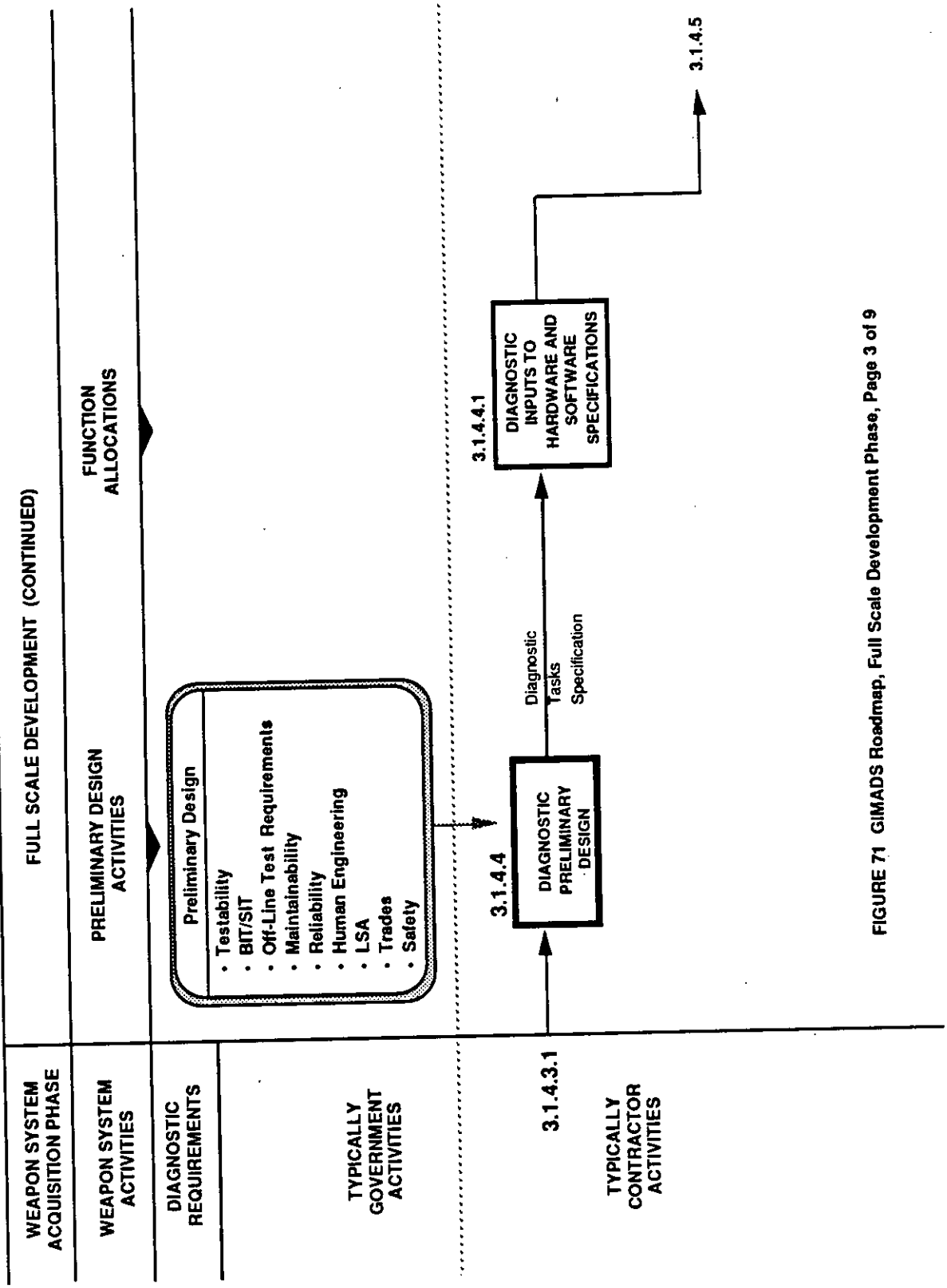

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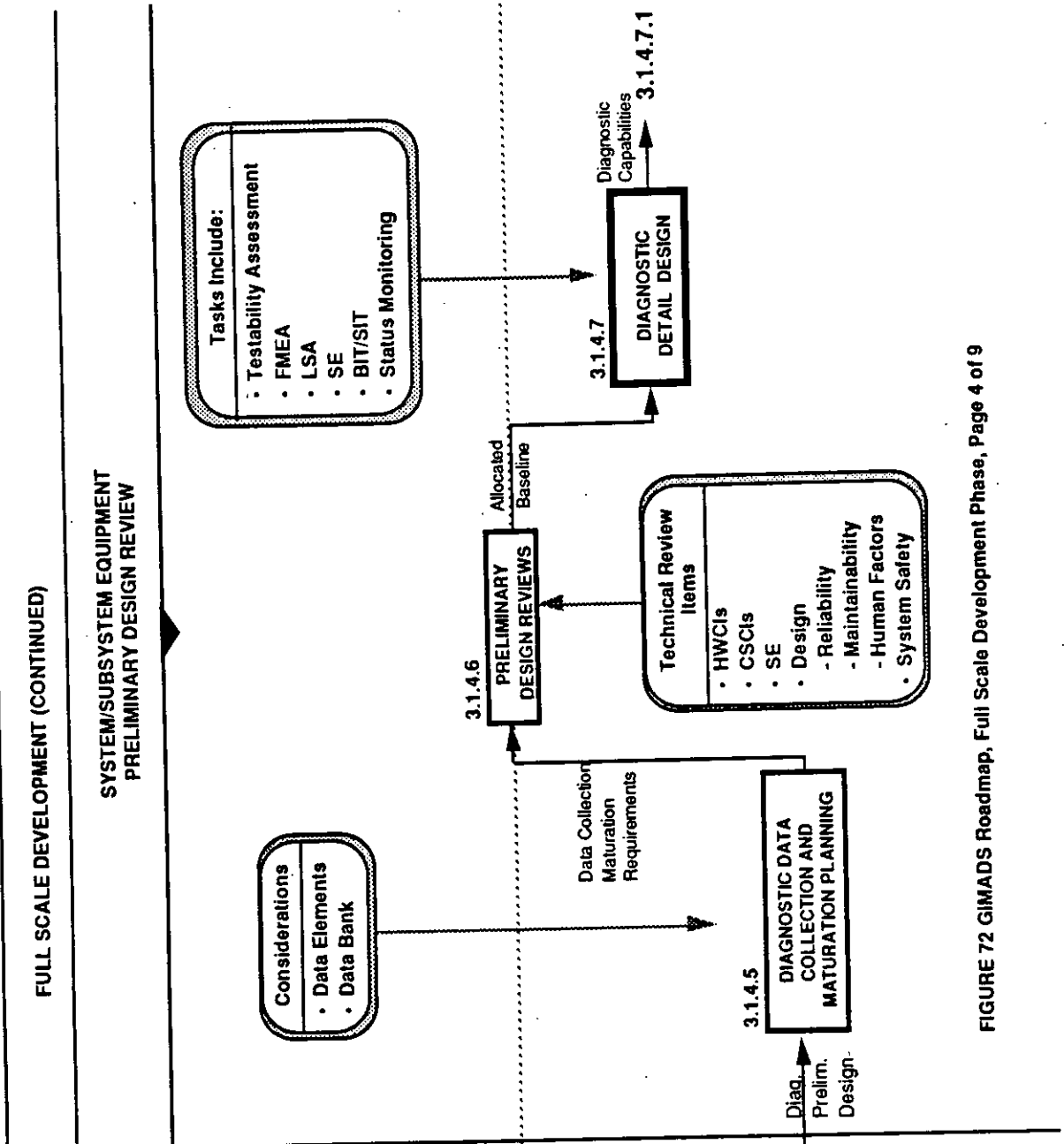

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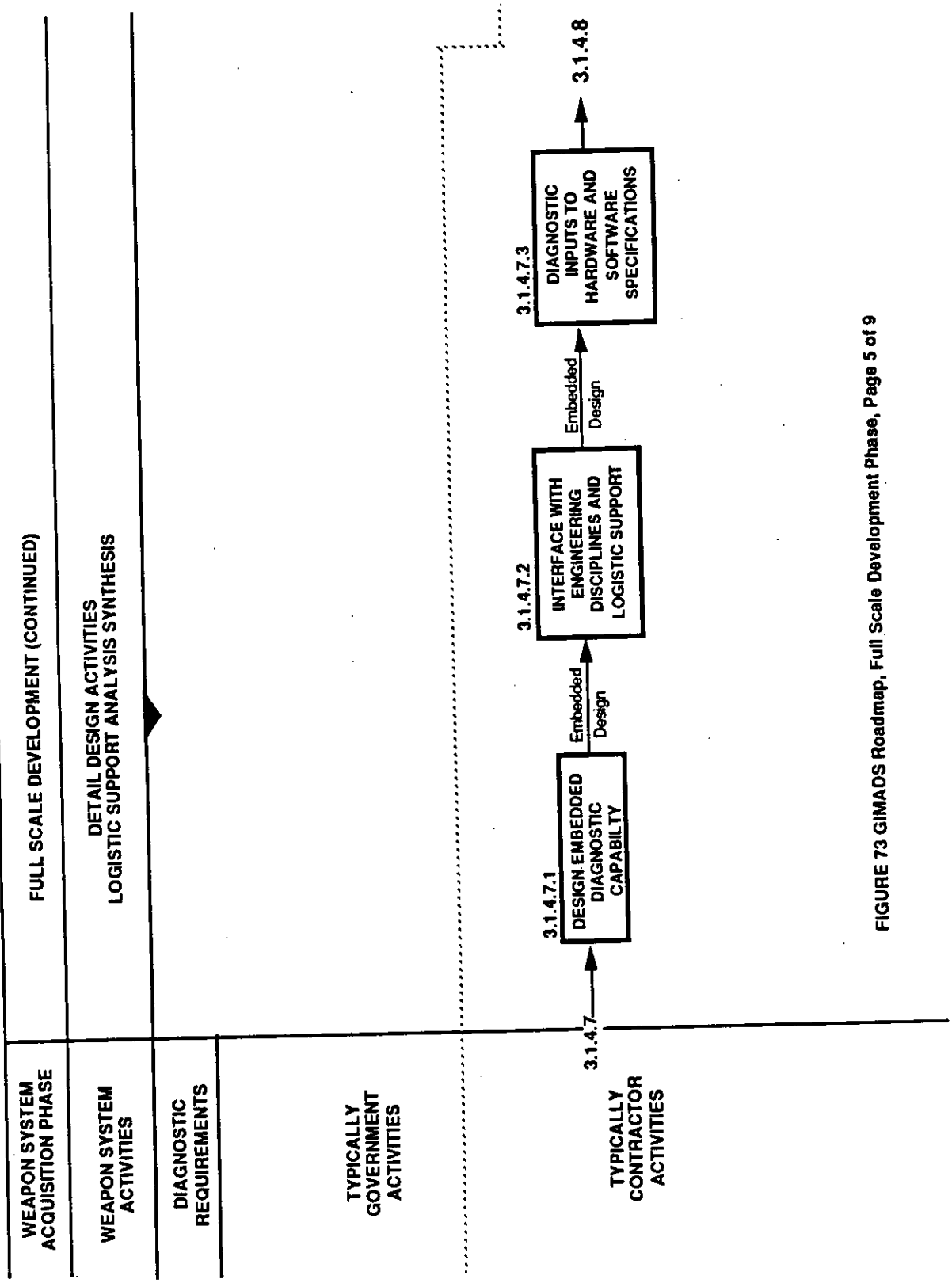

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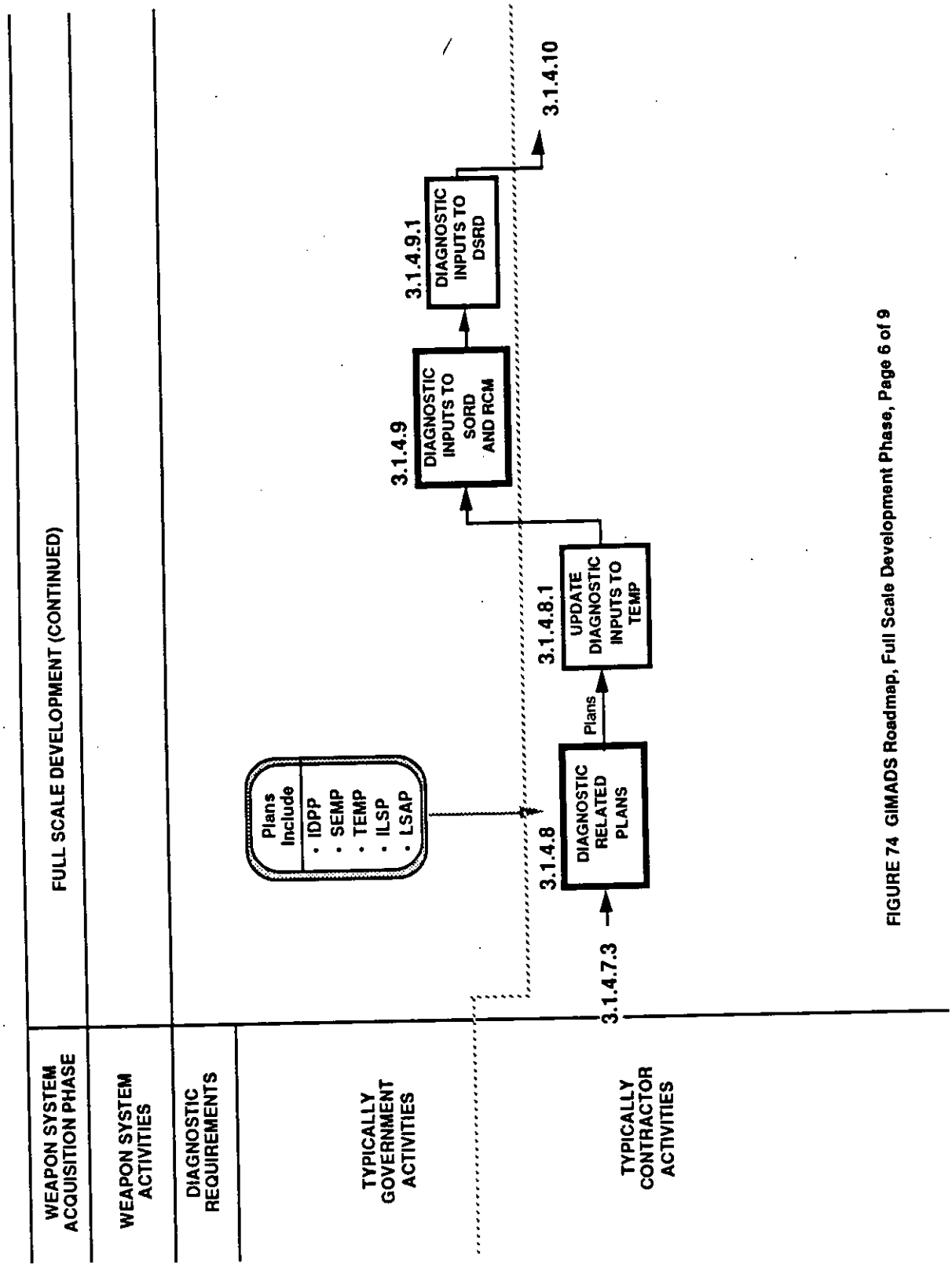

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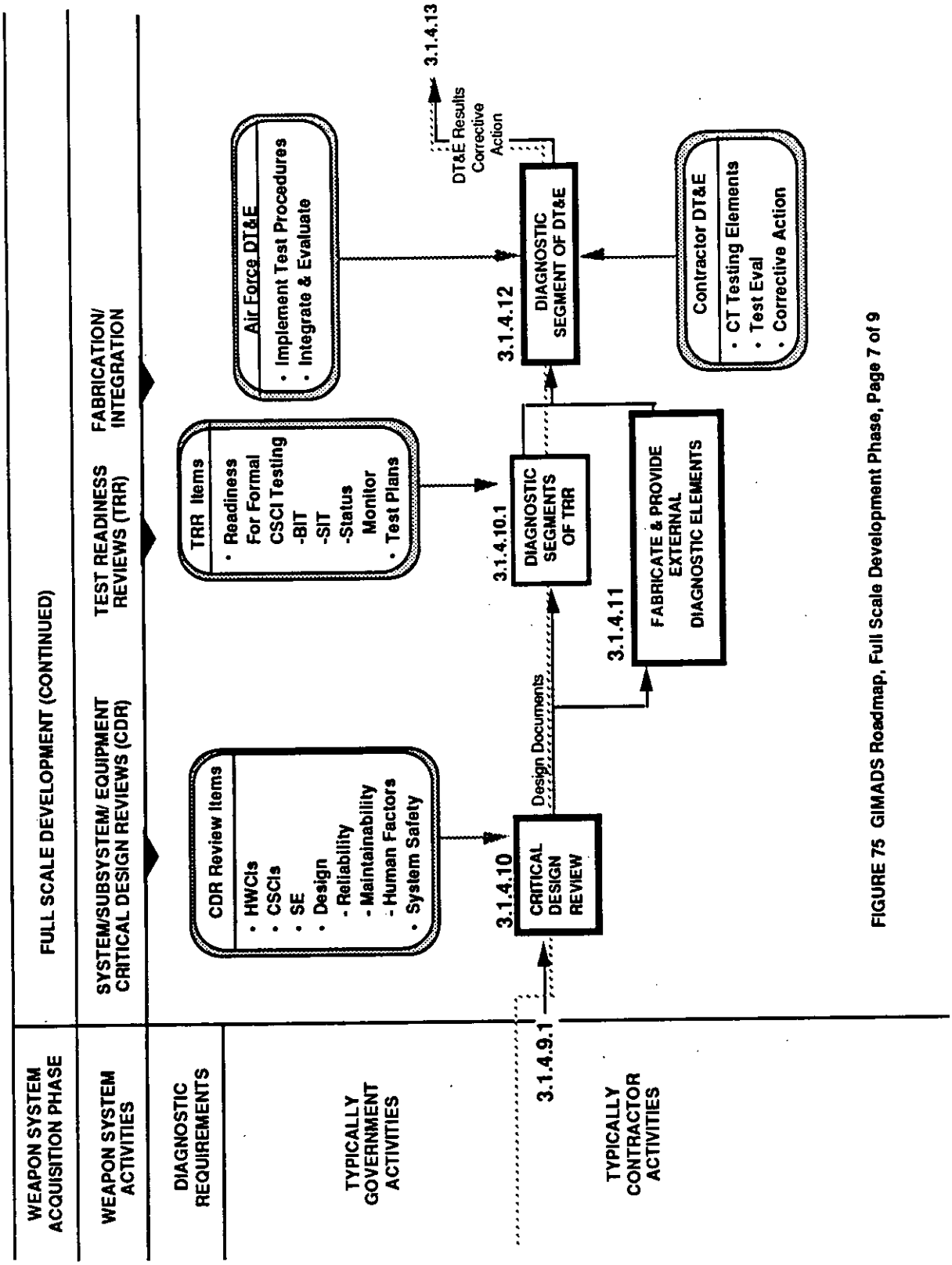

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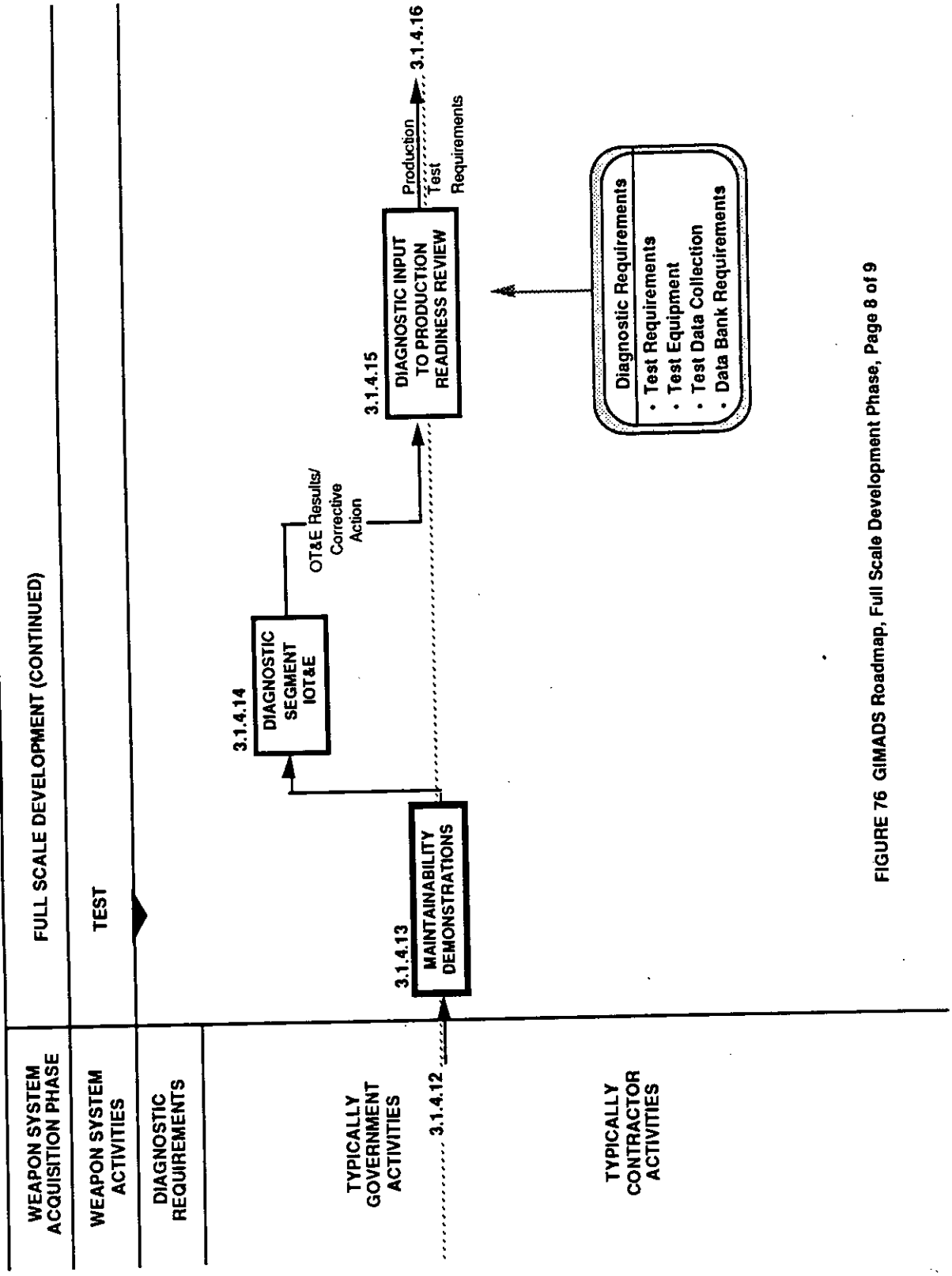

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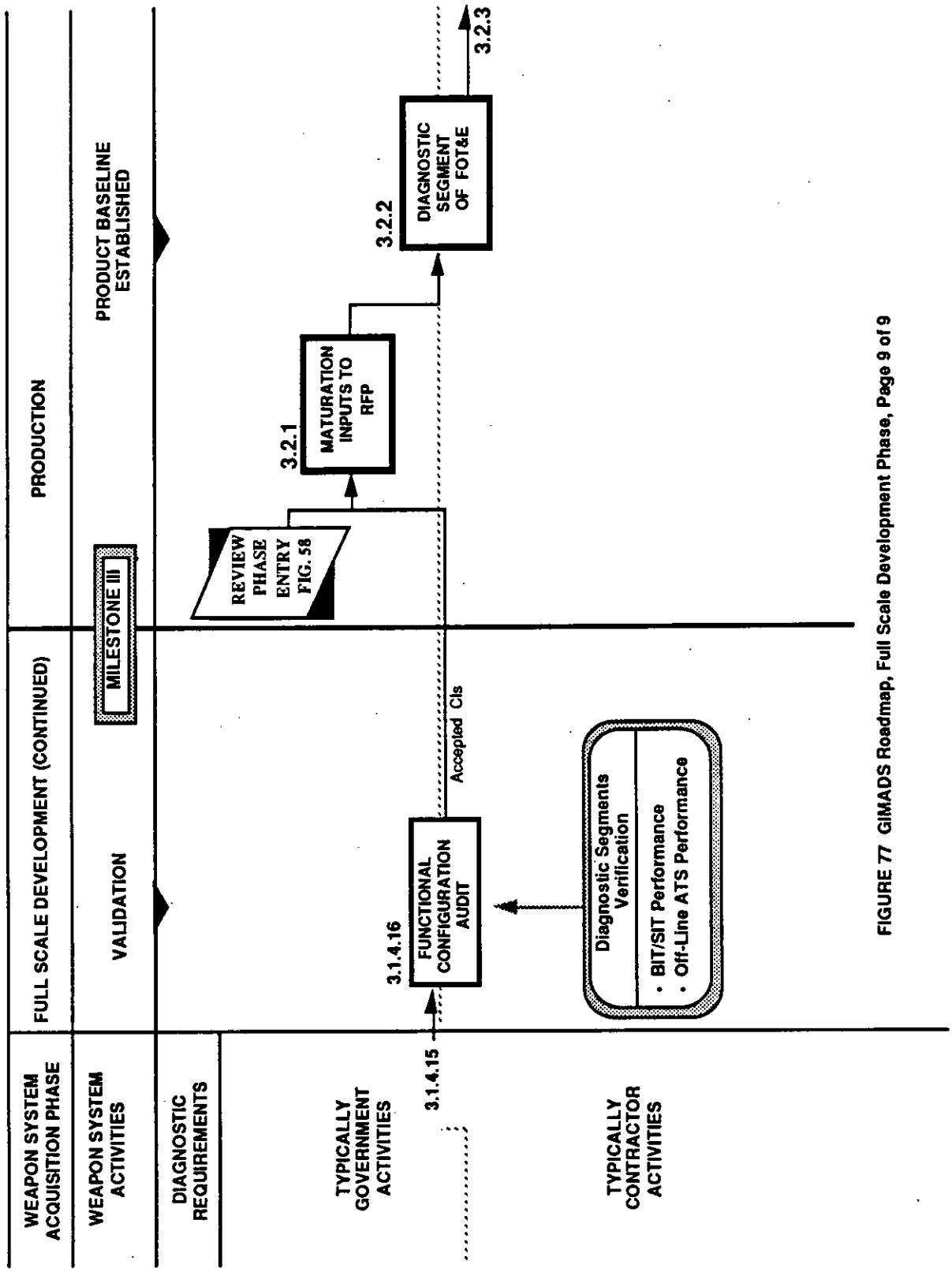

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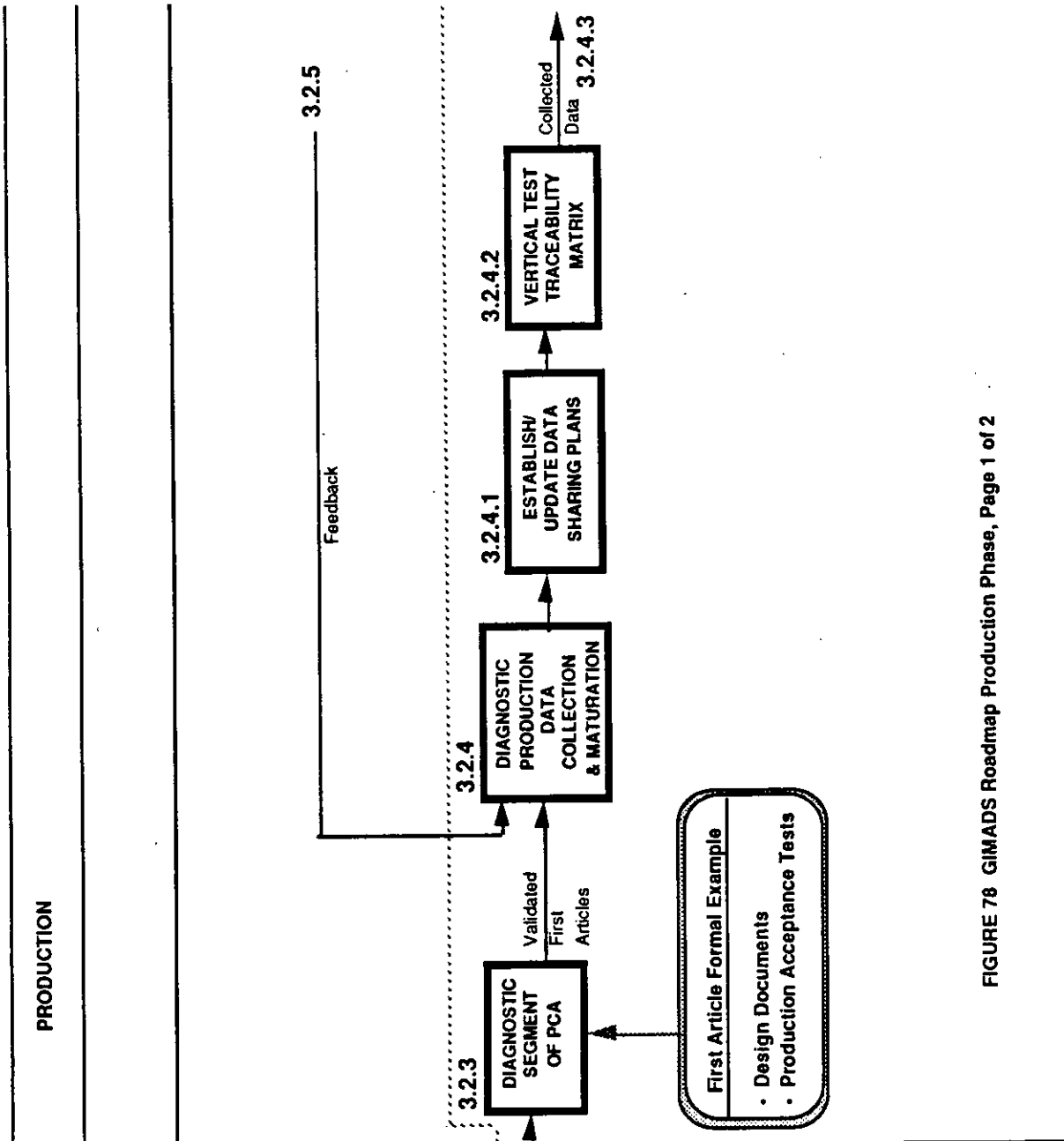

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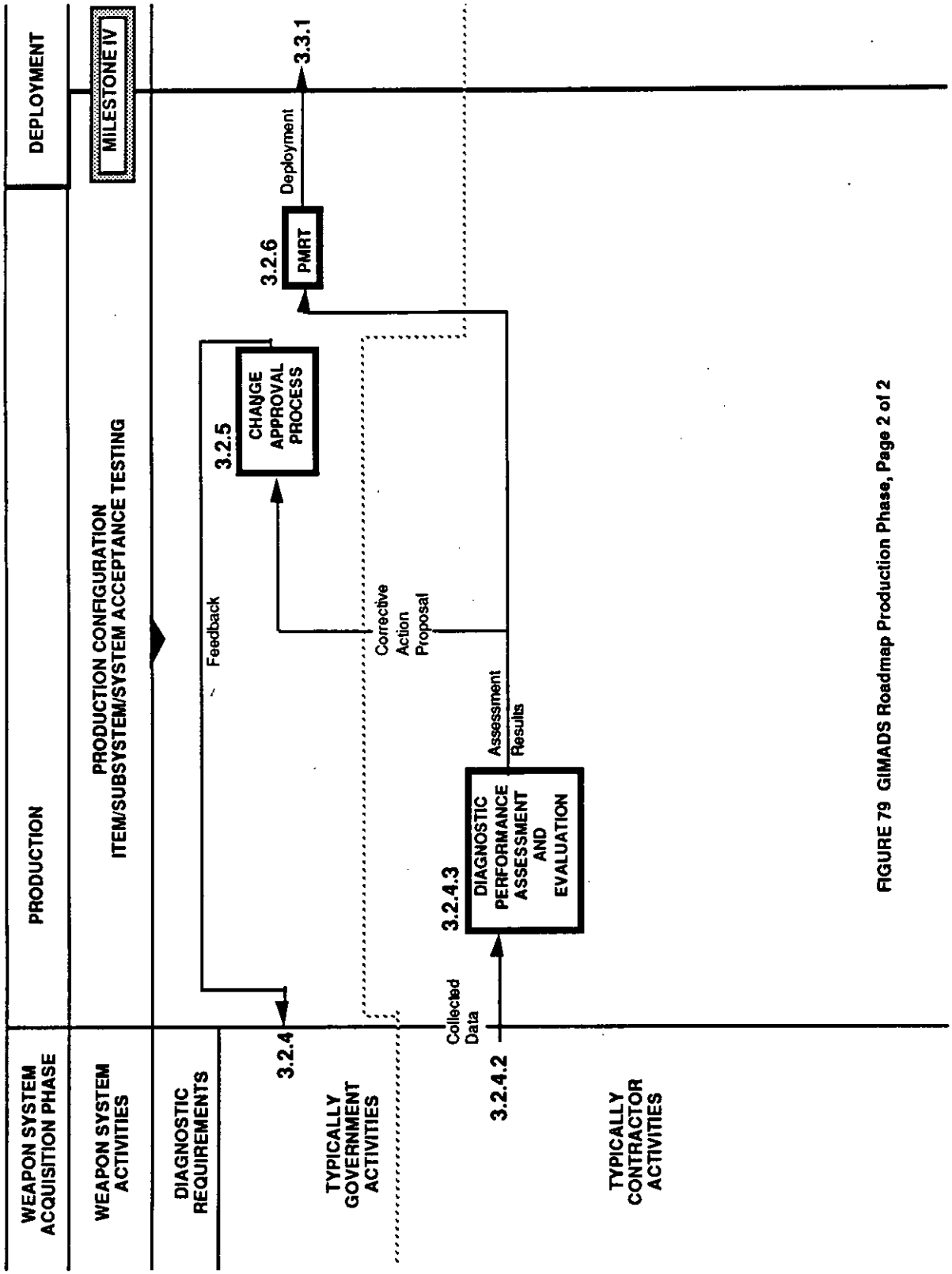

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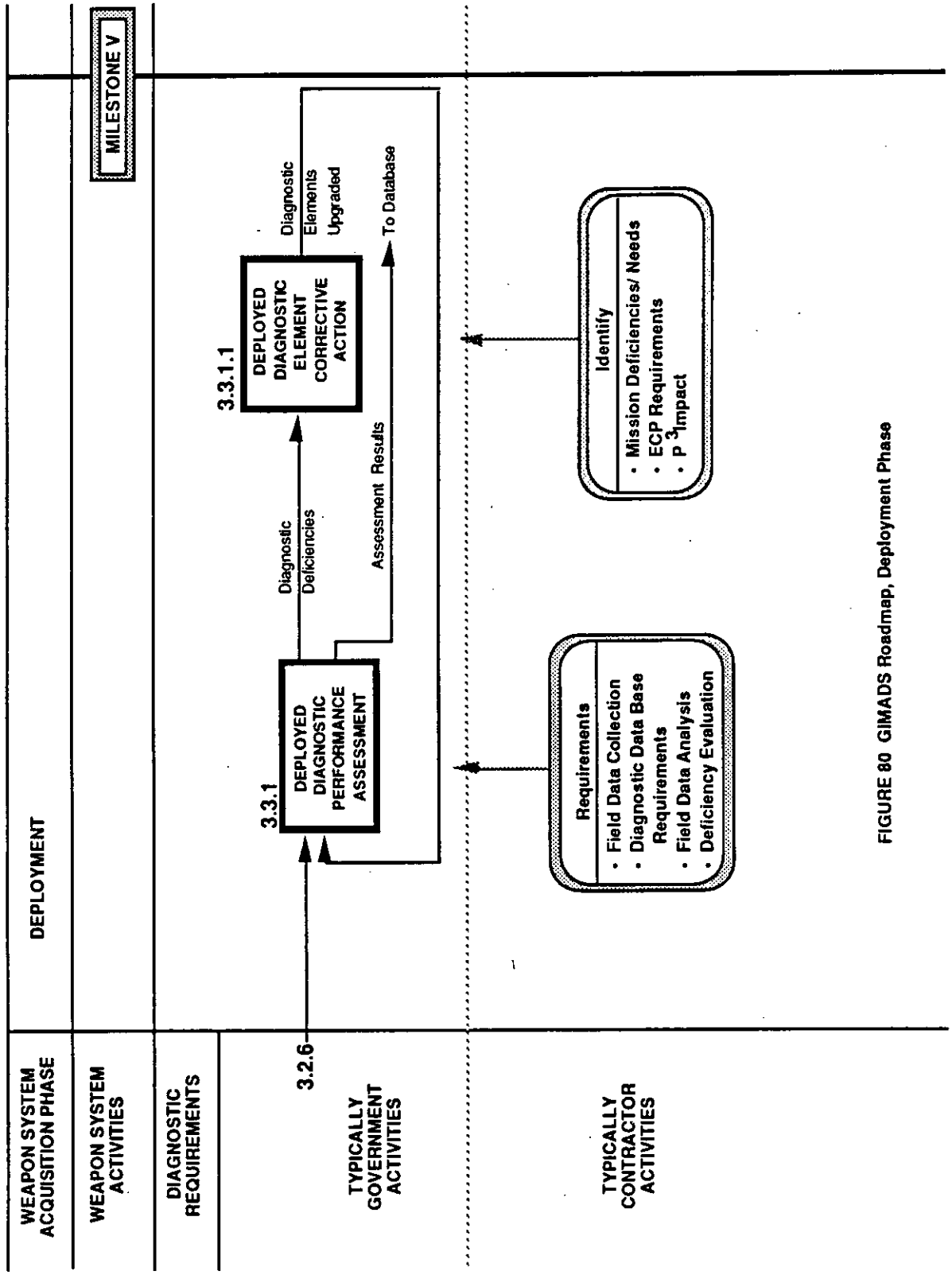

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CONCLUDING MATERIAL

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