MIL-STD-785B
15 September 1980

SUPERSEDING
MIL-STD-785A
28 March 1969

MILITARY STANDARD

RELIABILITY PROGRAM

FOR

SYSTEMS AND EQUIPMENT

DEVELOPMENT AND PRODUCTION

FSC RELI

AMSC Number F3104

DEPARTMENT OF DEFENSE
Washington, D. C. 20301

RELIABILITY PROGRAM FOR SYSTEMS AND EQUIPMENT DEVELOPMENT AND PRODUCTION

MIL-STD-785B

1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.

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

FOREWORD

This military standard consists of basic application requirements, specific tailorable reliability program tasks, and an appendix which includes an application matrix and guidance and rationale for task selection.

Effective reliability programs must be tailored to fit program needs and constraints, including life cycle costs (LCC). This document is intentionally structured to discourage indiscriminate blanket applications. Tailoring is forced by requiring that specific tasks be selected and, for those tasks identified, that certain essential information relative to implementation of the task be provided by the procuring activity.

Many of the tasks solicit facts and recommendations from the contractors on the need for, and scope of, the work to be done rather than requiring that a specific task be done in a specific way. The selected tasks can be tailored to meet specific and peculiar program needs.

Although not all encompassing, the guidance and rationale provided in Appendix A is intended to serve as an aid in selecting and scoping the tasks and requirements.

This revision contains the following fundamental changes from MIL-STD-785A:

a. Increased emphasis has been placed on reliability engineering tasks and tests. The thrust is toward prevention, detection, and correction of design deficiencies, weak parts, and workmanship defects. Emphasis on reliability accounting has been retained, and expanded to serve the needs of acquisition, operation, and support management, but cost and schedule investment in reliability demonstration (qualification and acceptance) tests must be made clearly visible and carefully controlled.

b. A sharp distinction has been established between basic reliability and mission reliability. Measures of basic reliability such as Mean-Time-Between-Failures (MTBF) now include all item life units (not just mission time) and all failures within the item (not just mission-critical failures of the item itself). Basic reliability requirements apply to all items.

c. Mission reliability (MIL-STD-785A "Reliability") is now one of four system reliability parameters. The other three are directly related to operational readiness, demand for maintenance, and demand for logistic support. Separate requirements will be established for each reliability parameter that applies to a system, and translated into basic reliablity requirements for subsystems, equipments, components, and parts.

CONTENTS

APPENDIX A

APPLICATION GUIDANCE FOR IMPLEMENTATION OF
RELIABILITY PROGRAM REQUIREMENTS

TABLES

RELIABILITY PROGRAM FOR SYSTEMS AND EQUIPMENT DEVELOPMENT AND PRODUCTION

1. SCOPE

1.1 Purpose. This standard provides general requirements and specific tasks for reliability programs during the development, production, and initial deployment of systems and equipment.

1.2 Applicability

1.2.1 Application of standard. Tasks described in this standard are to be selectively applied in DOD contract-definitized procurements, request for proposals, statements of work, and Government in-house developments requiring reliability programs for the development, production, and initial deployment of systems and equipment. The word "contractor" herein also includes Government activities developing military systems and equipment.

1.2.2 Tailoring of task descriptions. Task descriptions are intended to be tailored as required by governing regulations and as appropriate to particular systems or equipment program type, magnitude, and funding. When preparing his proposal, the contractor may include additional tasks or task modifications with supporting rationale for each addition or modification.

1.2.2.1 The "Details To Be Specified" paragraph under each task description is intended for listing the specific details, additions, modifications, deletions, or options to the requirements of the task that should be considered by the procuring activity when tailoring the task description to fit program needs. "Details" annotated by an "(R)" are essential and shall be provided the contractor for proper implementation of the task.

1.2.3 Application guidance. Application guidance and rationale for selecting tasks to fit the needs of a particular reliability program is included in appendix A; this appendix is not contractual.

1.3 Method of reference. When specifying the task descriptions of this standard as requirements, both the standard and the specific task description number(s) are to be cited. Applicable "Details To Be Specified" shall be included in the statement of work.

2. REFERENCED DOCUMENTS

2.1 Government documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein:

STANDARDS

MILITARY

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-721	Definitions of Terms For Reliability and Maintainability
MIL-STD-781	Reliability Design Qualification and Production Acceptance Tests: Exponential Distribution
MIL-STD-965	Parts Control Program

PUBLICATIONS

MILITARY HANDBOOK

MIL-HDBK-217 Reliability Prediction of Electronic Equipment

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

3. TERMS, DEFINITIONS, AND ACRONYMS

3.1 Terms. The terms used herein are defined in MIL-STD-721.

3.2 Definitions. Definitions applicable to this standard are as follows:

a. Tailoring: The process by which the individual requirements (sections, paragraphs, or sentences) of the selected specifications and standards are evaluated to determine the extent to which each requirement is most suitable for a specific materiel acquisition and the modification of these requirements, where necessary, to assure that each tailored document invoked states only the minimum needs of the Government. Tailoring is not a license to specify a zero reliability program, and must conform to provisions of existing regulations governing reliability programs.

b. Acquisition phases:

(1) Conceptual (CONCEPT) phase: The identification and exploration of alternative solutions or solution concepts to satisfy a validated need.

(2) Demonstration and validation (VALID) phase: The period when selected candidate solutions are refined through extensive study and analyses; hardware development, if appropriate; test; and evaluations.

(3) Full-scale engineering development (FSED) phase: The period when the system and the principal items necessary for its support are designed, fabricated, tested and evaluated.

(4) Production (PROD) phase: The period from production approval until the last system is delivered and accepted.

c. Reliability accounting: That set of mathematical tasks which establish and allocate quantitative reliability requirements, and predict and measure quantitative reliablity achievements.

d. Reliability engineering: That set of design, development, and manufacturing tasks by which reliability is achieved.

e. Basic reliability: The duration or probability of failure-free performance under stated conditions. Basic reliability terms, such as Mean-Time-Between Failures (MTBF) or Mean-Cycles-Between-Failures (MCBF), shall include all item life units (not just mission time) and all failures within the items (not just mission-critical failures at the item level of assembly). Basic reliability requirements shall be capable of describing item demand for maintenance manpower (e.g., Mean-Time-Between-Maintenance Actions(MTBMA)). The other system reliability parameters shall employ clearly defined subsets of all item life units and all failures.

f. Mission reliability: The ability of an item to perform its required functions for the duration of a specified mission profile.

g. Life units: A measure of use duration applicable to the item (e.g., operating hours, cycles, distance, rounds fired, attempts to operate).

h. Environmental stress screening (ESS). A series of tests conducted under environmental stresses to disclose weak parts and workmanship defects for correction.

i. Reliability development/growth test (RDGT): A series of tests conducted to disclose deficiencies and to verify that corrective actions will prevent recurrence in the operational inventory. (Also known as "TAAF" testing.)

j. Reliability qualification test (RQT): A test conducted under specified conditions, by, or on behalf of, the government, using items representative of the approved production configuration, to determine compliance with specified reliability requirements as a basis for production approval. (Also known as a "Reliablity Demonstration", or "Design Approval", test.)

k. Production reliability acceptance test (PRAT): A test conducted under specified conditions, by, or on behalf of, the government, using delivered or deliverable production items, to determine the producer's compliance with specified reliability requirements.

3.3 Acronyms. Acronyms used in this document are defined as follows:

CDR	-	Critical Design Review
CDRL	-	Contract Data Requirements List
CFE	-	Contractor Furnished Equipment
DID	-	Data Item Description(s)
ESS	-	Environmental Stess Screening
FMECA	-	Failure Modes, Effects, and Criticality Analysis(es)
FRACAS	-	Failure Reporting, Analysis(es), and Corrective Action Systems
FRB	-	Failure Review Board
FSED	-	Full Scale Engineering Development
GFE	-	Government Furnished Equipment
GIDEP	-	Government/Industry Data Exchange Program
GPR	-	Government Plant Representative(s)
LSAP	-	Logistic Support Analysis Program
LSAR	-	Logistic Support Analysis Records
MCBF	-	Mean-Cycles-Between-Failures
MCSP	-	Mission Completion Success Probability
MTBC	-	Mission-Time-Between-Critical Failures
MTBDE	-	Mean-Time-Between-Downing Events
MTBF	-	Mean-Time-Between-Failures
MTBMA	-	Mean-Time-Between-Maintenance Actions
MTBR	-	Mean-Time-Between-Removals
PA	-	Procuring Activity (including Program/Project Offices)

PCB	-	Parts Control Board
PDR	-	Preliminary Design Review
PPSL	-	Program Parts Selection List
PRAT	-	Production Reliability Acceptance Test
PRST	-	Probability Ratio Sequential Test
RDGT	-	Reliability Development/Growth Test
RFP	-	Request For Proposal
RQT	-	Reliability Qualification Test
SCA	-	Sneak Circuit Analysis(es)
SOW	-	Statement Of Work
TAAF	-	Test, Analyze, and Fix

4. GENERAL REQUIREMENTS

4.1 Reliability program. The contractor shall establish and maintain an efficient reliability program to support economical achievement of overall program objectives. To be considered efficient, a reliability program shall clearly: (1) improve operational readiness and mission success of the major end-item; (2) reduce item demand for maintenance manpower and logistic support; (3) provide essential management information; and (4) hold down its own impact on overall program cost and schedule.

4.2 Program requirements. Each reliability program shall include an appropriate mix of reliability engineering and accounting tasks depending on the life cycle phase. These tasks shall be selected and tailored according to the type of item (system, subsystem or equipment) and for each applicable phase of the acquisition (CONCEPT, VALID, FSED, and PROD). They shall be planned, integrated and accomplished in conjunction with other design, development and manufacturing functions. The overall acquisition program shall include the resources, schedule, management structure, and controls necessary to ensure that specified reliability program tasks are satisfactorily accomplished.

4.2.1 Reliability engineering. Tasks shall focus on the prevention, detection, and correction of reliability design deficiencies, weak parts, and workmanship defects. Reliability engineering shall be an integral part of the item design process, including design changes. The means by which reliability engineering contributes to the design, and the level of authority and constraints on this engineering discipline, shall be identified in the reliability program plan. An efficient reliability program shall stress early investment in reliability engineering tasks to avoid subsequent costs and schedule delays.

4.2.2 Reliablity accounting. Tasks shall focus on the provision of information essential to acquisition, operation, and support management, including properly defined inputs for estimates of operational effectiveness and ownership cost. An efficient reliability program shall provide this information while ensuring that cost and schedule investment in efforts to obtain management data (such as demonstrations, qualification tests, and acceptance tests) is clearly visible and carefully controlled.

4.3 Reliability program interfaces. The contractor shall utilize reliability data and information resulting from applicable tasks in the reliability program to satisfy LSAP requirements. All reliability data and information used and provided shall be based upon, and traceable to, the outputs of the reliability program for all logistic support and engineering activities involved in all phases of the system/subsystem/equipment acquisition.

4.4 Quantitative requirements. The system/subsystem/equipment reliability requirements shall be specified contractually. Quantitative reliability requirements for the system, all major subsystems, and equipments shall be included in appropriate sections of the system and end item specifications. The sub-tier values not established by the procuring activity shall be established by the system or equipment contractor at a contractually specified control point prior to detail design.

4.4.1 Categories of quantitative requirements. There are three different categories of quantitative reliability requirements: (1) operational requirements for applicable system reliability parameters; (2) basic reliability requirements for item design and quality; and (3) statistical confidence/decision risk criteria for specific reliability tests. These categories must be carefully delineated, and related to each other by clearly defined audit trails, to establish clear lines of responsibility and accountability.

4.4.2 System reliability parameters. System reliability parameters shall be defined in units of measurement directly related to operational readiness, mission success, demand for maintenance manpower, and demand for logistic support, as applicable to the type of system. Operational requirements for each of these parameters shall include the combined effects of item design, quality, operation, maintenance and repair in the operational environment. Examples of system reliability parameters include: readiness, Mean-Time-Between-Downing Events (MTBDE); mission success, Mission-Time-Between-Critical Failures (MTBCF); maintenance demand, Mean-Time-Between-Maintenance Actions (MTBMA); and logistics demand, Mean-Time-Between-Removals (MTBR).

4.4.3 Statistical criteria. Statistical criteria for reliability demonstrations, Reliability Qualification Tests (RQT), and Production Reliability Acceptance Tests (PRAT) shall be carefully tailored to avoid driving cost or schedule without improving reliability. Such criteria include specified confidence levels or decision risks, "Upper Test MTBF," "Lower Test MTBF," etc., as embodied in statistical test plans. They shall be clearly separated from specified values and minimum acceptable values to prevent test criteria from driving item design. They shall be selected and tailored according to the degree that confidence intervals are reduced by each additional increment of total test time.

4.4.3.1 Electronic equipment. For electronic equipment, the "Lower Test MTBF" shall be set equal to the minimum acceptable MTBF for the item. Conformance to the minimum acceptable MTBF requirements shall be demonstrated by tests selected from MIL-STD-781, or alternative specified by the PA.

4.4.3.2 Munitions and mechanical equipment. For munitions and mechancial equipment, a given lower confidence limit shall be set equal to the minium acceptable reliability for the item. An adequate number of samples shall be selected per MIL-STD-105, or by other valid means approved by the PA, and tested for conformance to reliability requirements as specified by the PA.

5. TASK DESCRIPTIONS

5.1 The task descriptions following are divided into three general sections: Section 100, Program Surveillance and Control; Section 200, Design and Evaluation; and Section 300, Development and Production Testing.

Custodians:
Army - CR
Navy - AS
Air Force - 11

Preparing Activity:
Air Force - 11

Project RELI-0008

Review Activities:
Army - AR, AV, AT, ME, MI, SC, TE
Navy - EC, OS, SA, SH, YD, TD, MC, CG
Air Force - 10, 13, 17, 18, 19, 26, 95

TASK SECTION 100

PROGRAM SURVEILLANCE AND CONTROL

THIS PAGE INTENTIONALLY LEFT BLANK

TASK 101

RELIABILITY PROGRAM PLAN

101.1 PURPOSE. The purpose of task 101 is to develop a reliability program plan which identifies, and ties together, all program management tasks required to accomplish program requirements.

101.2 TASK DESCRIPTION

101.2.1 A reliablity program plan shall be prepared and shall include, but not be limited to, the following:

a. A description of how the reliability program will be conducted to meet the requirements of the SOW.

b. A detailed description of how each specified reliability accounting and engineering design task(s) will be performed or complied with.

c. The procedures (wherever existing procedures are applicable) to evaluate the status and control of each task, and identification of the organizational unit with the authority and responsibility for executing each task.

d. Description of interrelationships of reliability tasks and activities and description of how reliability tasks will interface with other system oriented tasks. The description shall specifically include the procedures to be employed which assure that applicable reliablity data derived from, and traceable to, the reliability tasks specified are integrated into the LSAP and reported on appropriate LSAR.

e. A schedule with estimated start and completion points for each reliability program activity or task.

f. The identification of known reliability problems to be solved, an assessment of the impact of these problems on meeting specified requirements, and the proposed solutions or the proposed plan to solve these problems.

g. The procedures or methods (if procedures do not exist) for recording the status of actions to resolve problems.

h. The designation of reliability milestones (includes design and test).

i. The method by which the reliability requirements are disseminated to designers and associated personnel.

j. Identification of key personnel for managing the reliability program.

k. Description of the management structure, including interrelationship between line, service, staff, and policy organizations.

l. Statement of what source of reliability design guidelines or reliability design review checklist will be utilized.

m. Description of how reliability contributes to the total design, and the level of authority and constraints on this engineering discipline.

n. Identification of inputs that the contractor needs from operation and support experience with a predecessor item or items. Inputs should include measured basic reliability and mission reliability values, measured environmental stresses, typical failure modes, and critical failure modes.

101.2.2 The contractor may propose additional tasks or modifications with supporting rationale for such additions or modifications.

101.2.3 When approved by the procuring activity and if incorporated into the contract, the reliability program plan shall become, together with the SOW, the basis for contractual compliance.

101.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

101.3.1 Details to be specified in the SOW shall include the following, as applicable:

(R) a. Identification of each reliability accounting and engineering design tasks.

(R) b. Identification of contractual status of the program plan.

c. Identification of additional tasks to be performed or additional information to be provided.

d. Identification of any specific indoctrination or training requirements.

e. Delivery identification of any data item required.

TASK 102

MONITOR/CONTROL OF SUBCONTRACTORS AND SUPPLIERS

102.1 PURPOSE. The purpose of task 102 is to provide the prime contractor and PA with appropriate surveillance and management control of subcontractors/suppliers reliability programs so that timely managment action can be taken as the need arises and program progress is ascertained.

102.2 TASK DESCRIPTION

102.2.1 The contractor shall insure that system elements obtained from suppliers will meet reliability requirements. This effort shall apply to CFE items obtained from any supplier whether in the first or any subsequent tier, or whether the item is obtained by an intra-company order from any element of the contractor's organization. All subcontracts shall include provisions for review and evaluation of the suppliers' reliability efforts by the prime contractor, and by the procuring activity at their discretion.

102.2.2 The contractor shall assure, and advise the PA, that his subcontractors' and suppliers' reliability efforts are consistent with overall system requirements, and that provisions are made for surveillance of their reliability activities. The contractor shall, as appropriate:

a. Incorporate quantitative reliability requirements in subcontracted equipment specifications.

b. Assure that subcontractors have a reliability program that is compatible with the overall program amd includes provisions to review and evaluate their supplier(s) reliability efforts.

c. Attend and participate in subcontractors' design reviews.

d. Review subcontractors' predictions and analyses for accuracy and correctness of approach.

e. Furnish subcontractors with data from testing or usage of their product when testing and usage are outside their control.

f. Review subcontractors' test plans, procedures, and reports for correctness of approach and test details.

g. Review subcontractors' progress reports.

h. Assure that subcontractors have, and are pursuing, a vigorous corrective action effort to eliminate causes of unreliability.

i. Reserve for himself and for the PA the right to send personnel into the subcontractors' facilities as necessary to monitor and evaluate the subcontractors' reliability programs and related activities.

j. Assure that subcontractors/suppliers will provide him with the necessary technical and administrative support for the items they supply during production and deployment of the hardware. This support may include failure analyses and corrective action for failures occurring in the total use environment, if specified under 102.2 herein.

k. Ensure that selected items (critical items, et cetera) obtained from suppliers are covered by specifications, drawings, and other technical documents and that the requirements called out adequately control those parameters and characteristics that may affect reliability of the end item.

l. Unless otherwise specified by the PA, conduct or control his subcontractors/suppliers reliability demonstration (qualification and acceptance) tests on behalf of the government to provide a defensible basis for determining the supplier's contractual compliance with quantitative reliability requirements.

102.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

102.3.1 Details to be specified in the SOW shall include the following, as applicable:

a. Notification requirements for attendance at "Special meetings", program reviews, PDR's, CDR's et cetera.

b. Responsible activity to conduct or control reliability demonstration (qualification and acceptance) tests on behalf of the government.

TASK 103

PROGRAM REVIEWS

103.1 PURPOSE. The purpose of task 103 is to establish a requirement for the prime (or associate) contractor to conduct reliability program reviews at specified points in time to assure that the reliability program is proceeding in accordance with the contractual milestones and that the weapon system, subsystem, equipment, or component quantitative reliability requirements will be achieved.

103.2 TASK DESCRIPTION

103.2.1 The reliability program shall be planned and scheduled to permit the contractor and the PA to review program status. Formal review and assessment of contract reliability requirements shall be conducted at major program points, identified as system program reviews, as specified by the contract. As the program develops, reliability progress shall also be assessed by the use of additional reliability program reviews as necessary. The contractor shall schedule reviews as appropriate with his subcontractors and suppliers and insure that the PA is informed in advance of each review.

103.2.2 The reviews shall identify and discuss all pertinent aspects of the reliability program such as the following, when applicable:

a. At the Preliminary Design Review (PDR):

(1) Updated reliability status including:

(a) Reliability modeling
(b) Reliability apportionment
(c) Reliability predictions
(d) FMECA
(e) Reliability content of specification
(f) Design guideline criteria
(g) Other tasks as identified.

(2) Other problems affecting reliability

(3) Parts program progress

(4) Reliability critical items program.

b. At the Critical Design Review (CDR):

(1) Reliability content of specifications

(2) Reliability prediction and analyses

(3) Parts program status

(4) Reliability critical items program

(5) Other problems affecting reliability

(6) FMECA

(7) Identification of circuit reference designators whose stress levels exceed the recommended parts application criteria.

(8) Other tasks as identified.

c. At Reliability Program Reviews:

(1) Discussion of those items reviewed at PDRs and CDRs

(2) Results of failure analyses

(3) Test schedule: start dates and completion dates

(4) Parts, design, reliability, and schedule problems

(5) Status of assigned action items

(6) Contractor assessment of reliability task effectiveness

(7) Other topics and issues as deemed appropriate by the contractor and the PA.

d. At the Test Readiness Review:

(1) Reliability analyses status, primarily prediction

(2) Test schedule

(3) Test profile

(4) Test plan including failure definition

(5) Test report format

(6) FRACAS implementation.

e. At the Production Readiness Review:

(1) Results of applicable RQT's

(2) Results of applicable reliability/growth testing.

103.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

103.3.1 Details to be specified in the SOW shall include the following, as applicable:

a. Advance notification to the PA of all scheduled reviews. The specific number of days advance notice should be contractual.

b. Recording of the results of the reviews.

c. Identification of PA and contractor follow-up methods on review of open items.

d. Identification of reviews other than system program reviews.

e. Delivery identification of any data item required.

THIS PAGE INTENTIONALLY LEFT BLANK

TASK 104

FAILURE REPORTING, ANALYSIS, AND CORRECTIVE ACTION SYSTEM (FRACAS)

104.1 PURPOSE. The purpose of task 104 is to establish a closed loop failure reporting system, procedures for analysis of failures to determine cause, and documentation for recording corrective action taken.

104.2 TASK DESCRIPTION

104.2.1 The contractor shall have a closed loop system that collects, analyzes, and records failures that occur for specified levels of assembly prior to acceptance of the hardware by the procuring activity. The contractor's existing data collection, analysis and corrective action system shall be utilized, with modification only as necessary to meet the requirements specified by the PA.

104.2.2 Procedures for initiating failure reports, the analysis of failures, feedback of corrective action into the design, manufacturing and test processes shall be identified. Flow diagram(s) depicting failed hardware and data flow shall also be documented. The analysis of failures shall establish and categorize the cause of failure.

104.2.3 The closed loop system shall include provisions to assure that effective corrective actions are taken on a timely basis by a follow-up audit that reviews all open failure reports, failure analyses, and corrective action suspense dates, and the reporting of delinquencies to management. The failure cause for each failure shall be clearly stated.

104.2.4 When applicable, the method of establishing and recording operating time, or cycles, on equipments shall be clearly defined.

104.2.5 The contractor's closed loop failure reporting system data shall be transcribed to Government forms only if specifically required by the procuring activity.

104.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

104.3.1 Details to be specified in the SOW shall include the following, as applicable:

a. Identification of the extent to which the contractor's FRACAS must be compatible with PA's data system.

(R) b. Identification of level of assembly for failure reporting.

c. Definitions for failure cause categories.

d. Identification of logistic support requirements for LSAR.

e. Delivery identification of any data item required.

THIS PAGE INTENTIONALLY LEFT BLANK

TASK 105

FAILURE REVIEW BOARD (FRB)

105.1 PURPOSE. The purpose of task 105 is to require the establishment of a failure review board to review failure trends, significant failures, corrective actions status, and to assure that adequate corrective actions are taken in a timely manner and recorded during the development and production phases of the program.

105.2 TASK DESCRIPTION

105.2.1 The FRB shall review functional/performance failure data from appropriate inspections and testing including subcontractor qualification, reliability, and acceptance test failures. All failure occurrence information shall be available to the FRB. Data including a description of test conditions at time of failure, symptoms of failure, failure isolation procedures, and known or suspected causes of failure shall be examined by the FRB. Open FRB items shall be followed up until failure mechanisms have been satisfactorily identified and corrective action initiated. The FRB shall also maintain and disseminate the status of corrective action implementation and effectiveness. Minutes of FRB activity shall be recorded and kept on file for examination by the procuring activity during the term of the contract. Contractor FRB members shall include appropriate representatives from design, reliability, system safety, maintainability, manufacturing, and parts and quality assurance activities. The procuring activity reserves the right to appoint a representative to the FRB as an observer. If the contractor can identify and utilize an already existing and operating function for this task, then he shall describe in his proposal how that function will be employed to meet the procuring activity requirements. This task shall be coordinated with Quality Assurance organizations to insure there is no duplication of effort.

105.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

105.3.1 Details to be specified in the SOW shall include the following, as applicable.

(R) a. The imposition of task 104 as a requisite task.

THIS PAGE INTENTIONALLY LEFT BLANK

TASK 201

RELIABILITY MODELING

201.1 PURPOSE. The purpose of task 201 is to develop a reliability model for making numerical apportionments and estimates to evaluate system/subsystem/equipment reliability.

201.2 TASK DESCRIPTION

201.2.1 A reliability mathematical model based on system/subsystem/equipment functions shall be developed and maintained. As the design evolves, a reliability block diagram shall be developed and maintained for the system/subsystem with associated allocations and predictions for all items in each reliability block. The reliability block diagram shall be keyed and traceable to the functional block diagram, schematics, and drawings, and shall provide the basis for accurate mathematical representation of reliability. Nomenclature of items used in reliability block diagrams shall be consistent with that used in functional block diagrams, drawings, and schematics, weight statements, power budgets, and specifications. The model outputs shall be expressed in terms of contractual reliability requirements and other reliability terms as specified. When required for the PROD phase, the model shall be updated to include hardware design changes.

201.2.2 The reliability mathematical model shall be updated with information resulting from reliability and other relevant tests as well as changes in item configuration, mission parameters and operational constraints. Inputs and outputs of the reliability mathematical model shall be compatible with the input and output requirements of the system and subsystem level analysis models.

201.2.3 Modeling techniques shall provide separate outputs for: (1) basic reliability, and (2) mission reliability, of the system/subsystem/equipment. A single series calculation of basic reliability, and the modeling techniques described in appendix A of MIL-HDBK-217 for mission reliablity, shall be used unless otherwise specified.

201.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

201.3.1 Details to be specified in the SOW shall include the following, as applicable:

a. Imposition of tasks 202 and 203 as requisite tasks in the FSED phase.

b. Identification of alternative modeling techniques.

(R) c. Identification of mission parameters and operational constraints.

d. [illegible] ic support coordinated reporting requirements for LSAR.

e. [illegible] tification of additional reliablity terms.

f. Delivery identification of any data item required.

THIS PAGE INTENTIONALLY LEFT BLANK

TASK 202

RELIABILITY ALLOCATIONS

202.1 PURPOSE. The purpose of task 202 is to assure that once quantitative system requirements have been determined, they are allocated or apportioned to lower levels.

202.2 TASK DESCRIPTION

202.2.1 Both basic reliability and mission reliability requirements shall be allocated to the level specified and shall be used to establish baseline requirements for designers. Requirements consistent with the allocations shall be imposed on the subcontractors and suppliers. The apportioned values shall be included in appropriate sections of procurement specifications, critical item specifications, and contract end item specifications. All allocated reliability values established by the contractor and included in contract end item specifications shall be consistent with the reliability model (see task 201) and any change thereto, and subject to procuring activity review.

202.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

202.3.1 Details to be specified in the SOW shall include the following, as applicable:

a. Imposition of tasks 201 and 203 as requisite tasks in the FSED phase.

(R) b. Identification of the level to which PA will require allocations to be made.

c. Logistic support coordinated reporting requirements for LSAR.

(R) d. Pertinent reliability information of any specified GFE. This information shall include the environmental/operational conditions under which the reliability information was derived.

e. Delivery identification of any data item required.

THIS PAGE INTENTIONALLY LEFT BLANK

TASK 203

RELIABILITY PREDICTIONS

203.1 PURPOSE. The purpose of task 203 is to estimate the basic reliability and mission reliability of the system/subsystem/equipment and to make a determination of whether these reliability requirements can be achieved with the proposed design.

203.2 TASK DESCRIPTION

203.2.1 Reliability predictions shall be made for the system, subsystem/equipment. When required, predictions shall account for, and differentiate between, each mode of item operation as defined in the item specification. Predictions shall be made showing: (1) basic reliability of the item during the life profile specified by the PA, to provide a basis for life cycle cost and logistics support analysis; and (2) mission reliability of the item during the mission profile(s) specified by the PA, to provide a basis for analysis of item operational effectiveness. These predictions shall be made using the associated reliability block diagram and failure rate data approved by, or provided by, the procuring activity. Items shall not be excluded from the MCSP or other mission reliability predictions unless substantiating documentation (such as FMECA) verify that the item failure has no influence on the required measure of mission reliability. Prior to such exclusions from the predictions, an assessment and approval shall be obtained from the procuring activity.

203.2.1.1 Failure rates other than those established at contract award may be used only upon approval of the procuring activity.

203.2.1.2 The permissible failure rate adjustment factors for standby operation and storage shall be as specifically agreed to by the procuring activity.

203.2.1.3 When the individual part operating conditions are defined, the prediction procedure in section 2 of MIL-HDBK-217, or PA approved alternative, shall be used.

203.2.1.4 If the part type and quantity is the only information available, the prediction procedure of section 3 of MIL-HDBK-217, or PA approved alternative, shall be used.

203.2.2 Predictions for electronic equipment shall be made using one of the two methods contained in MIL-HDBK-217, or alternatives approved or provided by the PA. Predictions for mechanical, electrical, and electro-mechanical equipment shall be made using either contractor data or alternatives, both of which shall require PA approval.

203.3 <u>DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)</u>

203.3.1 Details to be specified in the SOW shall include the following, as applicable:

a. Imposition of tasks 201 and 202 as requisite tasks in the FSED phase.

b. Identification of dormancy factors.

(R) c. Identification of item life profile, to include one or more mission profiles.

d. Identification of requirement to update predictions using actual experience and test data.

e. Source from which failure rate data will be obtained (i.e., MIL-HDBK-217, or other sources).

f. Establishment of PA approval requirements for failure rate data and source of data.

g. Identification of alternative methods to be used for predictions.

h. Logistic support coordinated reporting requirements for LSAR.

i. Identification of additional reliability terms for which predictions are required.

(R) j. Pertinent reliability information of any specified GFE. This information shall include the environmental/operational conditions under which the reliability information was derived.

k. Delivery identification of any data item required.

TASK 204

FAILURE MODES, EFFECTS, AND CRITICALITY ANALYSIS (FMECA)

204.1 PURPOSE. The purpose of task 204 is to identify potential design weaknesses through systematic, documented consideration of the following: all likely ways in which a component or equipment can fail; causes for each mode; and the effects of each failure (which may be different for each mission phase).

204.2 TASK DESCRIPTION

204.2.1 FMECA shall be performed to the level specified (subsystem, equipment, functional circuit, module, or piece part level). All failure modes shall be postulated at that level and the effects on all higher levels shall be determined. The FMECA shall consider failure mode, failure effect and criticality (impact on safety, readiness, mission success, and demand for maintenance/logistics support), and the failure indication to the operator and maintenance personnel by life/mission profile phase. This analysis shall be scheduled and completed concurrently with the design effort so that the design will reflect analysis conclusions and recommendations. The results and current status of FMECA shall be used as inputs to design trade-offs, safety engineering, maintenance engineering, maintainability, logistic support analysis, test equipment design and test planning activities, et cetera.

204.2.2 A sample FMECA worksheet format shall be submitted to the PA for approval and details such as who (by discipline) shall perform the analysis, who shall review it for adequacy and accuracy, when and how it shall be updated, and what specific uses shall be made of the results (e.g., identifying potential system weaknesses, as a tool for evaluating the effectiveness of built-in test, updating reliability assessments, updating critical item control procedures, development of safety, maintainability, and human engineering design and operational criteria, et cetera) shall be identified.

204.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

204.3.1 Details to be specified in the SOW shall include the following, as applicable:

(R) a. Identification of the level to which the FMECA shall be conducted.

(R) b. Procedure identification in accordance with MIL-STD-1629, or an alternative approved by the PA.

(R) c. Identification of life/mission profile.

d. Logistic support coordinated reporting requirements for LSAR.

e. Submittal of sample FMECA worksheets per 204.2.2.

f. Delivery identification of any data items required.

THIS PAGE INTENTIONALLY LEFT BLANK

TASK 205

SNEAK CIRCUIT ANALYSIS (SCA)

205.1 PURPOSE. The purpose of task 205 is to identify latent paths which cause occurrence of unwanted functions or inhibit desired functions, assuming all components are functioning properly.

205.2 TASK DESCRIPTION

205.2.1 Sneak circuit analyses of critical circuitry shall be conducted to identify latent paths which cause unwanted functions to occur or which inhibit desired functions. In making these analyses, all components shall be assumed to be functioning properly. These analyses shall be made using production manufacturing documentation for each circuit analyzed.

205.2.2 A list of those functions/circuits to be analyzed, and the priorities given each subassembly in the analysis, shall be presented for PA approval at CDR, together with the supporting rationale for the selections made. Results of the analyses and actions taken as a result of analyses findings shall be made available to the procuring activity upon request.

205.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

205.3.1 Details to be specified in the SOW shall include the following, as applicable:

(R) a. Specification of criteria for selection of circuits/functions to be analyzed.

b. Delivery identification of any data items required.

THIS PAGE INTENTIONALLY LEFT BLANK

TASK 206

ELECTRONIC PARTS/CIRCUITS TOLERANCE ANALYSIS

206.1 PURPOSE. The purpose of task 206 is to examine the effects of parts/circuits electrical tolerances and parasitic parameters over the range of specified operating temperatures.

206.2 TASK DESCRIPTION

206.2.1 Parts/circuits tolerance analyses shall be conducted on critical circuitry as defined in the contract. These analyses shall verify that, given reasonable combinations of within-specification characteristics and parts tolerance buildup, the circuitry being analyzed will perform within specification performance. In making these analyses the contractor shall examine the effect of component parasitic parameters, input signal and power tolerances, and impedance tolerances on electrical parameters, both at circuit nodes (component interconnections) and at input and output points. Since all of the stated factors may not be significant to all circuits, only the critical factors for that circuit shall be considered.

206.2.2 Component characteristics, (life-drift and temperature) shall be factored into the analyses. These characteristics or values shall include resistance, capacitance, transistor, gain, relay opening or closing time, et cetera.

206.2.3 The inductance of wire-wound resistors, parasitic capacitance, and any other similar phenomena shall be taken into account, where appropriate. Maximum variations in input signal or power supply voltage, frequency, bandwidth, impedance, phase, et cetera shall be used in the analyses. The impedance characteristics of the load shall be considered as well. Circuit node parameters (including voltage, current, phase, and waveform), circuit element rise time, timing of sequential events, circuit power dissipation, and circuit-load impedance matching under worst case conditions shall also be considered. These parameters shall be analyzed for their effect on the performance of circuit components.

206.2.4 A list of those functions/circuits to be analyzed shall be presented at PDR. The most unfavorable combination of realizable conditions to be considered in the parts/circuits tolerance analyses shall be defined for approval by the procuring activity. Results of the analyses and actions taken as a result of analyses findings shall be made available to the procuring activity upon request.

206.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

206.3.1 Details to be specified in the SOW shall include the following, as applicable:

(R) a. Identification of range of equipment operating temperatures.

(R) b. Specification of criteria for selection of parts/circuits to be analyzed.

c. Delivery identification of any data items required.

TASK 207

PARTS PROGRAM

207.1 PURPOSE. The purpose of task 207 is to control the selection and use of standard and nonstandard parts.

207.2 TASK DESCRIPTION

207.2.1 A parts control program shall be established in accordance with MIL-STD-965 procedures, as designated in the contract.

207.2.2 Reliability design guidelines shall be developed and documented to include derating criteria, junction temperatures, and parts application criteria. Safety margins for nonelectronic parts will also be included when appropriate. The guidelines shall be consistent with guidance provided by the PA.

207.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

207.3.1 Details to be specified in the SOW shall include the following, as applicable:

(R) a. Identification of MIL-STD-965 procedures (procedure I or II).

b. Identification of PA part approval procedures.

c. Identification of review procedures with design activity.

d. Identification of detailed design guidelines, including:

(1) Order of preference of part quality/reliability/screening levels.

(2) Documentation of a prohibited parts/materials list.

e. Contractor/supplier participation in the GIDEP program per MIL-STD-1556.

THIS PAGE INTENTIONALLY LEFT BLANK

TASK 208

RELIABILITY CRITICAL ITEMS

208.1 <u>PURPOSE.</u> The purpose of task 208 is to identify and control those items which require "special attention" because of complexity, application of advanced state-of-the-art techniques, and the impact of potential failure on safety, readiness, mission success, and demand for maintenance/logistics support.

208.2 <u>TASK DESCRIPTION</u>

208.2.1 Reliability critical items shall be identified by FMECA or other methods and shall be controlled. Methods and procedures for control and testing of the reliability critical items shall be identified along with justification(s) for decontrolling the item if that is intended. When specified, the procedures shall include engineering support of critical items during FSED government field testing, which shall include provisions for confirming failures which may occur, expediting failure cause determination, and determining and incorporating, or verifying, the necessary corrective action.

208.3 <u>DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)</u>

208.3.1 Details to be specified in the SOW shall include the following, as applicable:

a. Specific identification of reliability critical item criteria such as:

(1) A failure of the item would critically affect system safety, cause the system to become unavailable or unable to achieve mission objectives, or cause extensive/expensive maintenance and repair. (NOTE: High-value items are reliability-critical for design-to-life-cycle cost.)

(2) A failure of the item would prevent obtaining data to evaluate system safety, availability, mission success, or need for maintenance/repair.

(3) The item has stringent performance requirement(s) in its intended application relative to state-of-the-art techniques for the item.

(4) The sole failure of the item causes system failure.

(5) The item is stressed in excess of specified derating criteria.

(6) The item has a known operating life, shelf life, or environmental exposure such as vibration, thermal, propellant; or a limitation which warrants controlled surveillance under specified conditions.

(7) The item is known to require special handling, transportation, storage, or test precautions.

(8) The item is difficult to procure or manufacture relative to

state-of-the-art techniques.

(9) The item has exhibited an unsatisfactory operating history.

(10) The item does not have sufficient history of its own, or similarity ot other items having demonstrated high reliability, to provide confidence in its reliability.

(11) The item's past history, nature, function, or processing has a deficiency warranting total traceability.

(12) The item is used in large quantities (typically, at least 10 percent of the configured items' electronic parts count).

b. Identification of requirements for engineering support during FSED field testing.

c. Logistic support coordinated reporting requirements for LSAR.

d. Delivery identification of any data items required.

TASK 209

EFFECTS OF FUNCTIONAL TESTING, STORAGE, HANDLING, PACKAGING, TRANSPORTATION, AND MAINTENANCE

209.1 PURPOSE. The purpose of task 209 is to determine the effects of storage, handling, packaging, transportation, maintenance, and repeated exposure to functional testing on hardware reliability.

209.2 TASK DESCRIPTION

209.2.1 Procedures shall be established, maintained, and implemented to determine by test and analysis, or estimation, the effects of storage, handling, packaging, transportation, maintenance, and repeated exposure to functional testing on the design and reliability of the hardware. The results of this effort shall include items such as:

a. Identification of equipments and their major or critical characteristics which deteriorate with storage age or environmental conditions (including shock and vibration, et cetera).

b. Identification of procedures for periodic field inspection or tests (including recall for test) or stockpile reliability evaluation. The procedures shall include suggested quantity of items for test and acceptable levels of performance for parameters under test.

c. Identification of special procedures for maintenance or restoration.

The results of this effort shall be used to support long term failure rate predictions, design trade-offs, definition of allowable test exposures, retest after storage decisions, packaging, handling, or storage requirements, and refurbishment plans.

209.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

209.3.1 Details to be specified in the SOW shall include the following, as applicable:

(R) a. Identification of functional testing, storage, handling, packaging, transportation, and maintenance profiles.

b. Logistic support coordinated reporting requirements for LSAR.

THIS PAGE INTENTIONALLY LEFT BLANK

TASK SECTION 300

DEVELOPMENT AND PRODUCTION TESTING

THIS PAGE INTENTIONALLY LEFT BLANK

TASK 301

ENVIRONMENTAL STRESS SCREENING (ESS)

301.1 PURPOSE. The purpose of task 301 is to establish and implement environmental stress screening procedures so that early failure(s) due to weak parts, workmanship defects, and other non-conformance anomolies can be identified and removed from the equipment.

301.2 TASK DESCRIPTION

301.2.1 Environmental stress screening (also known as preconditioning, burn-in, et cetera) shall be conducted on parts, subassemblies, and complete units for both developmental and production items.

301.2.1.1 During development, ESS test procedures, taking into consideration the equipment design, part/component technology, and production fabrication techniques, shall be formulated. ESS procedures shall be designed for the end item and for all lower level items which will be procured separately as spare or repair parts. A plan for implementing these procedures shall also be prepared, indicating the proposed application of ESS during development and production. The proposed ESS procedures and implementation plan shall be subject to approval by the PA.

301.2.2 ESS testing shall be designed to stimulate relevant failures by stressing the item. The stressing need not simulate the precise operational environment the item will see. Environmental stress types may be applied in sequence. During ESS, the item shall be cycled through its operational modes while simultaneously being subjected to the required environmental stresses.

301.2.3 Upon approval of the proposed ESS procedures and implementation plan, a detailed environmental stress screening test plan shall be prepared and included as part of the reliability test plan. The ESS detailed test plan shall include the following, subject to PA approval prior to initiation of testing:

a. Description of environmental stress types, levels, profiles, and exposure times to be applied.

b. Identification of level (board, subassembly, assembly) at which testing will be accomplished.

c. Identification of item perforamnce and stress parameters to be monitored during ESS.

d. Proposed test duration (failure-free interval and maximum ESS test time per item).

301.2.4 The results of ESS testing during development shall be analyzed and used as the basis for the ESS procedures to be specified for production.

301.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

301.3.1 Details to be specified in the SOW shall include the following, as applicable:

a. Identification of the requirement to develop ESS procedures, implementation plan, and detailed test plan.

b. Specification of detailed ESS requirements.

c. Delivery identification of any data items required.

TASK 302

RELIABILITY DEVELOPMENT/GROWTH TEST (RDGT) PROGRAM

302.1 Purpose. The purpose of task 302 is to conduct pre-qualification testing (also known as TAAF) to provide a basis for resolving the majority of reliability problems early in the development phase, and incorporating corrective action to preclude recurrence, prior to the start of production.

302.2 TASK DESCRIPTION

302.2.1 A reliability development/growth test (TAAF test) shall be conducted for the purpose of enhancing system reliability through the identification, analysis, and correction of failures and the verification of the corrective action effectiveness. Mere repair of the test item does not constitute corrective action.

302.2.1.1 To enhance mission reliability, corrective action shall be focused on mission-critical failure modes. To enhance basic reliability, corrective action shall be focused on the most frequent failure modes regardless of their mission criticality. These efforts shall be balanced to meet predicted growth for both parameters.

302.2.1.2 Growth testing will emphasize performance monitoring, failure detection, failure analysis, and the incorporation and verification of design corrections to prevent recurrence of failures.

302.2.2 A TAAF test plan shall be prepared and shall include the following, subject to PA approval prior to initiation of testing:

a. Test objectives and requirements, including the selected growth model and growth rate and the rationale for both selections.

b. Identification of the equipment to be tested and the number of test items of each equipment.

c. Test conditions, environmental, operational and performance profiles, and the duty cycle.

d. Test schedules expressed in calendar time and item life units, including the test milestones and test program review schedule.

e. Test ground rules, chargeability criteria and interface boundaries.

f. Test facility and equipment descriptions and requirements.

g. Procedures and timing for corrective actions.

h. Blocks of time and resources designated for the incorporation of design corrections.

i. Data collection and recording requirements

j. FRACAS

k. Government furnished property requirements

l. Description of preventive maintenance to be accomplshed during test

m. Final disposition of test items

n. Any other relevant considerations.

302.2.3 As specified by the procuring activity, the TAAF test plan shall be submitted to the procuring activity for its review and approval. This plan, as approved, shall be incorporated into the contract and shall become the basis for contractual compliance.

302.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

302.3.1 Details to be specified in the SOW shall include the following, as applicable:

(R) a. Imposition of task 104 as a requisite task.

(R) b. Identification of a life/mission/environmental profile to represent equipment usage in service.

c. Identification of equipment and quantity to be used for reliability development/growth testing.

d. Delivery identification of any data items required.

TASK 303

RELIABILITY QUALIFICATION TEST (RQT) PROGRAM

303.1 PURPOSE. The purpose of task 303 is to determine that the specified reliability requirements have been achieved.

303.2 TASK DESCRIPTION

303.2.1 Reliability qualification tests shall be conducted on equipments which shall be identified by the PA and which shall be representative of the approved production configuration. The reliability qualification testing may be integrated with the overall system/equipment qualification testing, when practicable, for cost-effectiveness; the RQT plan shall so indicate in this case. The PA shall retain the right to disapprove the test failure relevancy and chargeability determinations for the reliability demonstrations.

303.2.2 A RQT plan shall be prepared in accordance with the requirements of MIL-STD-781, or alternative approved by the PA, and shall include the following, subject to PA approval prior to initiation of testing:

a. Test objectives and selection rationale.

b. Identification of the equipment to be tested (with identification of the computer programs to be used for the test, if applicable) and the number of test items of each equipment.

c. Test duration and the appropriate test plan and test environments. The test plan and test environments (if life/mission profiles are not specified by the PA) shall be derived from MIL-STD-781. If it is deemed that alternative procedures are more appropriate, prior PA approval shall be requested with sufficient selection rationale to permit procuring activity evaluation.

d. A test schedule that is reasonable and feasible, permits testing of equipment which are representative of the approved production configuration, and allows sufficient time, as specified in the contract, for PA review and approval of each test procedure and test setup.

303.2.3 Detailed test procedures shall be prepared for the tests that are included in the RQT plan.

303.2.4 As specified by the procuring activity, the RQT plan and test procedures shall be submitted to the procuring activity for its review and approval. These documents, as approved, shall be incorporated into the contract and shall become the basis for contractual compliance.

303.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

303.3.1 Details to be specified in the SOW shall include the following, as applicable:

(R) a. Identification of equipment to be used for reliability qualification testing.

(R) b. Identification of MIL-STD-781, MIL-STD-105 or alternative procedures to be used for conducting the RQT (i.e., test plan, test conditions, etc.).

c. Identification of a life/mission/environmental profile to represent equipment usage in service.

d. Logistic support coordinated reporting requirements for LSAR.

e. Delivery identification of any data items required.

TASK 304

PRODUCTION RELIABILTY ACCEPTANCE TEST (PRAT) PROGRAM

304.1 PURPOSE. The purpose of task 304 is to assure that the reliability of the hardware is not degraded as the result of changes in tooling, processes, work flow, design, parts quality, or other characteristics identified by the PA.

304.2 TASK DESCRIPTION

304.2.1 Production reliability acceptance testing shall be conducted on production equipments which shall be identified by the procuring activity.

304.2.2 A PRAT plan shall be prepared in accordance with the requirements of MIL-STD-781, or alternative approved by the PA, and shall include the following, subject to PA approval prior to initiation of testing:

a. Test objectives and selection rationale.

b. Identification of the equipment to be tested and the number of test samples of each equipment.

c. Test duration, test frequency, and the appropriate test plan and test environments. The test plan and test environments (if mission profiles are not specified by the PA) shall be derived from MIL-STD-781. If it is deemed that alternative procedures are more appropriate, prior PA approval shall be requested with sufficient selection rationale to permit procuring activity evaluation.

d. A test schedule that is reasonable and feasible, and in consonance wityh the production delivery schedule.

304.2.3 Detailed test procedures shall be prepared for the tests that are included in the PRAT plan or the equipment specification.

304.2.4 As specified by the procuring activity, the PRAT plan and procedures shall be submitted to the procuring activity for its review and approval. These documents, as approved by the procuring activity, shall be incorporated into the contract and shall become the basis for contractual compliance.

304.3 DETAILS TO BE SPECIFIED BY THE PA (reference 1.2.2.1)

304.3.1 Details to be specified in the SOW shall include the following, as applicable:

(R) a. Identification of equipment to be used for production reliability acceptance testing.

(R) b. Identification of MIL-STD-781, MIL-STD-105 or alternative procedures to be used for conducting the PRAT (i.e., test plan, test conditions, etc.).

c. Identification of a mission/environmental profile to represent equipment usage.

d. Logistic support coordinated reporting requirements for LSAR.

e. Delivery identification of any data items required.

APPENDIX A

APPLICATION GUIDANCE FOR IMPLEMENTATION OF RELIABILITY PROGRAM REQUIREMENTS

10. GENERAL

10.1 Scope. This appendix provides rationale and guidance for the selection of tasks to fit the needs of any reliability program, and identifies applicable data items for implementation of required tasks.

10.2 Purpose. This appendix is to be used to tailor reliability requirements in the most cost effective manner that meets established program objectives. HOWEVER, IT IS NOT TO BE REFERENCED, OR IMPLEMENTED, IN CONTRACTUAL DOCUMENTS.

10.3 User. The user of this appendix may include the Department of Defense procuring activity, Government in-house activity, and prime contractor, or subcontractor, who wishes to impose reliability tasks upon his supplier(s).

20. REFERENCED DOCUMENTS

MIL-E-5400	Electronic Equipment, Airborne, General Specification For
MIL-Q-9858	Quality Program Requirements
MIL-P-11268	Parts, Materials, and Processes Used in Electronic Equipment
MIL-STD-781	Reliability Design Qualification and Production Acceptance Tests, Exponential Distribution
MIL-STD-810	Environment Test Methods
MIL-STD-965	Parts Control Program
MIL-STD-1521	Technical Reviews and Audits ForSystems, Equipment, And Computer Programs
MIL-STD-1556	Government/Industry Data Exchange Program Contractor Participation Requirements
MIL-HDBK-217	Reliability Prediction of Electronic Equipment

30. DEFINITIONS

Reference MIL-STD-785 basic.

40. TASK SELECTION

40.1 Selection criteria

40.1.1 A major problem which confronts all government and industry organizations responsible for a reliability program is the selection of tasks which can materially aid in attaining program reliability requirements. Today's schedule and funding constraints mandate a cost-effective selection, one that is based on identified program needs. The considerations presented herein are intended to provide guidance and rationale for this selection. They are also intended to jog the memory for "lessons learned" to provoke questions which must be answered and to encourage dialogue with other engineers, operations and support personnel so that answers to questions and solutions to problems can be found.

40.1.2 Once appropriate tasks have been selected, the tasks themselves can be tailored as outlined in the "Details To Be Specified By The PA." It is also important to coordinate task requirements with other engineering support groups, such as Logistics Support, System Safety, et cetera, to eliminate duplication of tasks and to be aware of any additional information of value to reliability which these other groups can provide. Finally, the timing and depth required for each task, as well as action to be taken based on task outcome, are largely dependent on individual experience and program requirements. For these reasons, hard and fast rules are not stated.

40.2 Application matrix for program phases. Table I herein provides general guidance, in summary form, of "when and what" to include in a RFP to establish an acceptable and cost effective reliability program. This table can be used to initially identify those tasks which typically are included in an effective reliability program for the particular acquisition phase involved. The user of the document can then refer to the particular task referenced by the matrix and determine from the detailed purpose at the beginning of the task if it is appropriate to identify as a program task. The use of this matrix for developing a reliability program is to be considered as optional guidance only and is not to be construed as covering all procurement situations. The provisions of applicable regulations must also be followed.

40.3 Task prioritization. The problem of prioritizing or establishing a base line group from all the tasks in this document cannot be solved unless variables like system complexity, program phase, availability of funds, schedule, et cetera are known. The reliability program plan (task 101) should always be considered for selection and total program complexity is one consideration for determining the need for this task. However, individual tasks may be cited without requiring a reliability program plan.

TABLE A-I. Application matrix

TASK	TITLE	TASK TYPE	PROGRAM PHASE			
			CONCEPT	VALID	FSED	PROD
101	RELIABILITY PROGRAM PLAN	MGT	S	S	G	G
102	MONITOR/CONTROL OF SUBCONTRACTORS AND SUPPLIERS	MGT	S	S	G	G
103	PROGRAM REVIEWS	MGT	S	S(2)	G(2)	G(2)
104	FAILURE REPORTING, ANALYSIS, AND CORRECTIVE ACTION SYSTEM (FRACAS)	ENG	NA	S	G	G
105	FAILURE REVIEW BOARD (FRB)	MGT	NA	S(2)	G	G
201	RELIABILITY MODELING	ENG	S	S(2)	G(2)	GC(2)
202	RELIABILITY ALLOCATIONS	ACC	S	G	G	GC
203	RELIABILITY PREDICTIONS	ACC	S	S(2)	G(2)	GC(2)
204	FAILURE MODES, EFFECTS, AND CRITICALITY ANALYSIS (FMECA)	ENG	S	S (1)(2)	G (1)(2)	GC (1)(2)
205	SNEAK CIRCUIT ANALYSIS (SCA)	ENG	NA	NA	G(1)	GC(1)
206	ELECTRONIC PARTS/CIRCUITS TOLERANCE ANALYSIS	ENG	NA	NA	G	GC
207	PARTS PROGRAM	ENG	S	S(2)(3)	G(2)	G(2)
208	RELIABILITY CRITICAL ITEMS	MGT	S(1)	S(1)	G	G
209	EFFECTS OF FUNCTIONAL TESTING, STORAGE, HANDLING, PACKAGING, TRANSPORTATION, AND MAINTENANCE	ENG	NA	S(1)	G	GC
301	ENVIRONMENTAL STRESS SCREENING (ESS)	ENG	NA	S	G	G
302	RELIABILITY DEVELOPMENT/GROWTH TESTING	ENG	NA	S(2)	G(2)	NA
303	RELIABILITY QUALIFICATION TEST (RQT) PROGRAM	ACC	NA	S(2)	G(2)	G(2)
304	PRODUCTION RELIABILITY ACCEPTANCE ACCEPTANCE TEST (PRAT) PROGRAM	ACC	NA	NA	S	G(2)(3)

CODE DEFINITIONS

TASK TYPE:

ACC - RELIABILITY ACCOUNTING

ENG - RELIABILITY ENGINEERING

MGT - MANAGEMENT

PROGRAM PHASE

S - SELECTIVELY APPLICABLE

G - GENERALLY APPLICABLE

GC - GENERALLY APPLICABLE TO DESIGN CHANGES ONLY

NA - NOT APPLICABLE

(1) - REQUIRES CONSIDERABLE INTERPRETATION OF INTENT TO BE COST EFFECTIVE

(2) - MIL-STD-785 IS NOT THE PRIMARY IMPLEMENTATION REQUIREMENT. OTHER MIL-STDS OR STATEMENT OF WORK REQUIREMENTS MUST BE INCLUDED TO DEFINE THE REQUIREMENTS.

50. RATIONALE AND GUIDANCE FOR TASK SECTIONS

50.1 Task section 100 - Program surveillance and control

50.1.1 Structuring the program requirements

50.1.1.1 Identifying and quantifying reliability needs. The elements of a reliability program must be selected to meet reliability needs. These needs are identified by higher authority through documentation such as the Decision Coordinating Paper (DCP), the Program Management Directive (PMD), and Program Management Plan (PMP). Identifying and quantifying these needs must be accomplished prior to release of an RFP for the appropriate acquisition phase so that tasks and requirements commensurate with the needs may be included in the RFP. The tasks and requirements which are included establish the framework for the continuing reliability dialogue between the procuring activity and the proposing contractors, one or more, of whom will ultimately be selected to develop the hardware. It is essential to make appropriate analyses and exercise mature judgment in determining reliability needs.

50.1.1.1.1 In making this determination, it is necessary to assemble program data concerning mission and performance requirements (preferably at the subsystem level), anticipated environments, and mission reliability and basic reliability requirements. This information is initially gathered in the CONCEPT phase and refined throughout development. It is the base upon which the reliability needs are determined and adjusted as this information is refined. The initial life/mission profile definition shall define, as a minimum, the boundaries of the performance envelope and provide the timeline (environmental conditions and applied/induced stresses versus time) typical of operations within that envelope. The quantitative requirements (basic reliability and mission reliability) shall be determined for the defined life/mission profile.

50.1.1.1.2 Using these data and the information on equipment contemplated to provide the required performance, a separate apportionment or allocation of basic reliability (MTBMA or MTBF) and mission reliability (MCSP or MTBCF) can be made to the equipment level. This apportionment is usually based on available reliability data modified to reflect changes in performance requirements (e.g., greater accuracy), duty cycles, and anticipated environments. If the hardware to be procured is a subsystem or equipment, the allocations discussed herein would apply down to the lowest assembly level in terms of MTBMA, MTBF, or failure rate. The required modifications are largely a matter of judgment, particularly when a new or considerably modified equipment concept must be synthesized to provide a specified function.

50.1.1.1.3 A reliability estimate should be made of each equipment independent of, and reasonably soon after, completing the initial apportionment. The equipment estimates should be combined to provide an initial estimate of basic reliability and mission reliability. During the CONCEPT and VALID phases design details will probably not be available. Therefore, estimates made during these phases and early in FSED will provide "ball park" numbers, which are nevertheless adequate for initial comparisons with, and for establishing the reasonableness of, the initial apportionment. Reapportionment based on a comparison with details of the estimate may be advisable at this time. The apportionment and the estimate procedures should be repeated until reasonable apportioned values are obtained. The apportionment should be frozen prior to the contractor's awarding subcontracts which have firm reliability requirements.

50.1.1.2 Selecting tasks to fit the needs. Some reliability tasks should be accomplished for an entire weapons system, e.g., develop and use an effective FRACAS, make periodic estimates of basic reliability and mission reliability. In most cases, the need for them is self evident. These same tasks, and others which must be selected, apply to subsystems and equipment. While experience plays a key role in task selection, it should be supplemented by analysis and investigation.

50.1.1.2.1 A useful initial analytical procedure is to compare reliability estimates at the subsystem and equipment level, with the corresponding apportionments. If the estimate is less than the apportionment, the need for improvement is indicated. Where "considerable" improvement is required (and "considerable" is a judgment), the subsystem or equipment should be identified as "reliability critical". This identification shall be as early as possible in the program phase so as to impact the equipment through the proper selection of tasks.

50.1.1.2.2 Reasons for the disparity between the apportioned and the estimated values of the reliability critical items should be investigated. Discussions of these reasons and tentative ways to attain the apportioned values, (e.g., relaxed performance requirements, either more or less design redundancy, additional environmental protection), should be held with appropriate project personnel. The object of the investigations and discussions is viable recommendation(s) for action to overcome the deficiencies. A significant benefit which can be gained from this process is a consensus on, and a wide awareness of, the specific equipment which is considered reliability critical. When systems or equipment performance requirements create a wide and irreconcilable disparity between apportioned and estimated values of required reliability, the procuring authority shall challenge the performance requirements. Elimination of less essential equipment functions can reduce equipment complexity and significantly enhance reliability.

50.1.1.2.3 Once recommendations for task applications have been determined and more detailed equipment requirements identified, tasks and requirements can be prioritized and a "rough order of magnitude" estimate should be made of the time and effort required to complete each task. This information will be of considerable value in selecting the tasks which can be accomplished within schedule and funding constraints.

50.1.1.3 Reliability program plan (task 101). The reliability program plan is to be designed as a basic tool for the PA to assist in managing an effective reliability program and to evaluate the contractor's approach to, understanding of, and execution of his reliability tasks, his depth of planning to ensure that his procedures for implementing and controlling reliability tasks are adequate, and his organizational structure to ensure that appropriate attention will be focused on reliability activities/problems.

50.1.1.4 Monitor/control of subcontractors and suppliers (task 102). The RFP contains system/subsystem/equipment requirements and some of the equipment will undoubtedly be designed and developed by subcontractors. Appropriate reliability tasks, previously determined as necessary, will also be included in the RFP, and are normally levied by the prime (or associate) or integrating contractor on the subcontractors. The procuring activity must know that these tasks and requirements are correctly understood by the subcontractors. This understanding is fundamental to meeting program needs.

50.1.1.4.1 Continual visibility of subcontractors' activities is essential so that timely and appropriate management action can be taken as the need arises. To this end, it is prudent to include contractual provisions which permit the procuring activity to participate, at its discretion, in appropriate formal prime/subcontractor meetings. Information gained at these meetings can provide a basis for follow-up action necessary to maintain adequate visibility of subcontractors' progress.

50.1.1.4.2 Active participation in the closed-loop FRACAS (50.1.2.3) should be required of all equipment subcontractors as well as the prime or integrating contractor. The information about unplanned events which this system can provide is a major factor in assessing and maintaining reliability program effectiveness. It is reasonable to assume that equipment failures will occur during service evaluation testing. During this testing it is very important to determine as rapidly as possible the cause of such failures, the need for corrective action, and the specific action to be taken. For this reason, selected subcontractor support of these tests is advisable, and should be considered by the procuring activity for inclusion in program requirements.

50.1.2 Program management

50.1.2.1 Continual program assessment. Since system acquisition programs are usually very dynamic, continual knowledge of program status is required to assure that necessary action can be taken expeditiously. Such knowledge can be obtained by integrating informal information with formal reporting.

50.1.2.1.1 One informal technique is to monitor program status through telephone conversations and visits to the contractor's facility. Such procedures should be established early in the program so that it can be agreed to by all parties. The resultant informal information system should be used early and exercised throughout development to expedite corrective action.

50.1.2.1.2 Useful information on program status can often be gleaned from contractor data which is not submitted formally, but which can be made available through an accession list. A data item for this list must be included in the CDRL. The list is a compilation of documents and data which the procuring activity can order, or which can be reviewed at the contractor's facility. Typically, the details of design analyses, test planning, test results, and technical decisions are included and the data constitute a source of information not otherwise available.

50.1.2.1.3 Active participation by the procuring activity or its designated representatives in the hardware testing programs (prime and subcontractor) will provide first hand information on test progress and thus an assessment of program status. The PA reliability monitor who is closely associated with contractor testing will be better able to alert program management to problem areas, and to identify corrective action contemplated or implemented to resolve the problems.

50.1.2.1.4 The informal methods described above provide timely information and should be used to the maximum extent consistent with PA resources. Such information is normally supplemented with reports which document reliability program activity and continuity, and which are submitted under the CDRL. These formal reports for reliability and related areas can include design data and analyses of test results, and are submitted at intervals as specified on the CDRL. The reports provide interim status in addition to documenting the completion of significant program milestones. Their utility depends on adequate PA review, which is especially important if approval is linked to approval to proceed to the next program phase.

50.1.2.2 Program reviews (task 103) An important management and technical tool used by the procuring activity reliability organization is Design Reviews. These reviews should be specified in the statement of work to ensure adequate staffing and funding. Typically, reviews are held: to evaluate the progress, consistency and technical adequacy, including reliability, of a selected design and test approach, (PDR); and to determine the acceptability of the detail design approach, including reliability, (CDR) before commitment to production. Both the procuring activity and contractor reliability personnel should consider design reviews as major milestones. The contractor's reliability organization should be represented at all design reviews whether conducted internally, with supplier, or with the Government. The result of the contractor's internal, and suppliers, design reviews should be documented and made available to the PA on request. Design reviews should include review of reliability items listed in task 103. (Reference MIL-STD-1521 for AF use.)

50.1.2.2.1 Reviews of the reliability program should also be conducted from time to time. Early in the program the reviews should be held at least quarterly and as the program progresses, time between reviews can be extended. In addition to more detailed coverage of those items discussed at PDRs and CDRs, the reviews should address progress on all reliability tasks specified in the statement of work. Representative discussion items include all reliability analyses, failure analysis details, test schedules and progress, problems related to vendors' and subs' reliability programs, parts problems and design problems. Reliability reviews should be specified and scheduled in the Statement of Work of task 103.

50.1.2.2.2 All reliability program reviews provide an opportunity to review and assign action items and to explore other areas of concern. A mutually acceptable agenda should be generated to ensure that all reliability open items are covered and that all participants are prepared for meaningful discussions.

50.1.2.3 Failure reporting, analysis, and corrective action systems (FRACAS) (task 104). Early elimination of failure causes is a major contributor to reliability growth and attaining acceptable field reliability. The sooner failure causes can be identified, the easier it is to implement effective corrective action. As the design, documentation and preliminary hardware mature, corrective action can still be identified, but its implementation becomes more difficult. It is, therefore, important to employ a closed-loop FRACAS early in the development phase. Except for non-complex acquisitions, FRACAS should be required by the procuring activity, and the contractor's existing system should be used with minimum changes necessary to accomplish the fundamental purposes of eliminating failure causes and documenting the action taken.

50.1.2.3.1 FRACAS effectiveness depends on accurate input data, i.e., reports documenting failures/anomalies and failure cause isolation. Essential inputs are made by the contractor's failure cause isolation. Also, essential inputs are made by the contractor's failure reporting activity which should span across all testing activities. These inputs should document all conditions surrounding a failure to facilitate failure cause determination. (If time permits, these observations should also be used to verify the FMECA (50.2.3.1) for correctness and consistency.) Sometimes failure causes can be determined through technical dialogue between design and reliability engineers. Occasionally, however, it is decided that formal laboratory failure analyses are required to reveal failure mechanisms and provide the basis for effective corrective action. Laboratory failure analysis should always be done for reliablity test failures if the part failure mode is germane to the failure cause determinations.

50.1.2.3.2 The disposition of failed hardware is critical and must be properly controlled to preclude premature disposal and ensure that the actual failed parts are subjected to required analyses. A disposition team (the Failure Review Board) is normally comprised of representatives of Government and contractor engineering, quality assurance and manufacturing. Access to hardware peripheral to the failed item may also be required to investigate failure repeatability under identical test/usage conditions. During initial development, demand for existing hardware often exceeds supply and can result in routing that is not easily traceable. A FRACAS should be flexible enough to accommodate normal operations, and yet be capable of tracking the equipment as it proceeds through the failure analysis activities. During later phases, the FRACAS should also be able to accommodate hardware returned from the customer and hardware returned to subcontractors and vendors for analysis.

50.1.2.3.3 A useful output of the FRACAS is a failure summary report which groups information about failure of like items or similar functional failures. With this information, the need for, and the extent of contemplated corrective action and its impact can be formulated.

50.1.2.4 Failure review board (FRB) (task 105). For the acquisition of expensive, complex, or critical systems or equipment it may be necessary and desirable to formalize FRACAS proceedings to the extent of having them controlled by a FRB.

50.1.2.4.1 The addition of this task to a reliability program will provide the procuring activity with further assurance of tight control of reporting, analysis, and corrective actions taken on identified failures. It should be noted, however, that in some instances the application of this task may duplicate QA tasks under MIL-Q-9858 and may not be cost effective or in the best interests of the overall program. Therefore, a survey should be made by the procuring activity to determine the need for application of this task.

50.1.2.5 Government plant representatives. The GPR (AFPRO, NAVPRO, and DCAS) serves as an extension of the procuring activity and provides on-site real-time feedback on the contractor's program activities. To assure maximum coordination and utilization of the GPR, a memorandum of agreement (MOA) or other documentation should be coordinated early in a program as to the kind of reliability support the GPR will provide. For example, the GPR can perform in-plant surveillance and test monitoring on a routine basis. In addition, ad hoc tasks and inquiries can be performed as needs develop. The GPR can also be a most valuable observer or participant in reliability program reviews (50.1.2.2).

50.1.3 Conducting the program

50.1.3.1 Essential considerations. When the technical tasks required to achieve the reliability requirements have been defined, the resources required must be identified and committed to meet objectives efficiently. The task elements should be staffed and time-phased to ensure that reliability objectives are not arbitrarily compromised to meet other program cost or schedule constraints.

50.1.3.1.1 The procuring activity reliability monitor can properly influence the contractor's reliability program by placing on contract: (1) numerical reliability requirements and the testing requirements to ensure contractual compliance during development and production; (2) the requirement to implement specific reliability tasks during conduct of the program and (3) the requirement to provide visibility to the procuring activity of the implementation of the contractual requirements.

50.1.3.1.2 Reliability program success requires that top management be continually informed of program status and unresolved problems that could impact the achievement of program milestones, so that direction and resources can be reoriented as required. In general, the contractor's reliablity organization should have: (1) a shared responsibility with other disciplines in its engineering department to achieve reliability (2) technical control of reliability disciplines; and (3) fiscal control of reliability resources.

50.1.3.1.3 Working arrangements between reliability and other activities (e.g., maintainability, safety, survivability, vulnerability, testing, quality assurance) should be established to identify mutual interests, maximize benefits of mutually supporting tasks, and minimize effort overlap. Such organizational working relationships can also promote more system-oriented decisions if the work is properly integrated at higher levels.

50.1.3.1.4 When all the necessary planning for a reliability program has been accomplished, it should be documented as a reliability program plan (task 101). A reliability program plan is normally submitted as part of the contractor's response to the procuring activity's request for proposals. After mutual agreement has been reached and procuring activity approval has been granted, the reliability program plan must be made a part of the contract. Since the plan is a contractual tool used to evaluate the contractor's reliability program, it should be kept current, subject to procuring activity approval.

50.1.3.2 Preparing for follow-on phases. From time to time during the acquisition program, transitions from one program phase to another have to be made. In addition, there may be other occasions within program phases when changes in the reliability program are required. As transition or other change points approach, those responsible for monitoring and achieving system reliability must evaluate the needs for the reliability program and determine its structure if it is needed.

50.1.3.2.1 While almost all tasks described in this standard can be performed at varying levels of detail during any acquisition phase, it is incumbent upon the procuring activity reliability monitor to ensure that only essential tasks are specified, to avoid wasting resources. The procuring activity and the contractor should critically appraise what has, or what will have been achieved, at given milestones. For example, as the transition between FSED and PROD approaches, judgments regarding reliability tasks during production must be made. In some instances, only some kind of minimal testing will be required, while in other instances, a substantial number of FSED tasks will need to be continued, along with some testing. Yet other cases may call for a reliability growth program or perhaps a phase-unique task such as PRAT. (The FSED-PROD transition point was chosen for illustrative purposes. Similar reasoning applies whenever program change points occur or are anticipated.) It is not the purpose of this paragraph to match a set of tasks with every conceivable set of program circumstances. Rather, its purpose is to emphasize that the reliability monitor must assess and project accomplishments, determine what still needs to be accomplished to achieve reliability requirements, and then tailor a program to meet those requirements.

NOTE: "Tailoring" should not be interpreted as license to specify a zero reliablity program. Necessity and sufficiency are the key criteria to be met in determining whether tasks are tailored into, or excluded from, a reliability program.

50.2 Task section 200 - Design and evaluation

50.2.1 General considerations

50.2.1.1 Criteria and analyses are resource allocation tools. Program funding and schedule constraints demand that the limited reliability resources available be used where they are most cost effective. It is also axiomatic that major program level requirements and criteria have a more far reaching impact than those developed for lower levels. It is appropriate, therefore, to examine as early as possible the numerical reliability requirements, both basic reliablity (MTBF, MTBMA, or failure rate) and mission reliability (MCSP, MTBCF, or critical failure rate), mission rules, failure tolerance criteria, et cetera, so that analyses can be selected to show design compliance or to identify shortcomings. During this examination the numerical requirements and criteria should also be evaluated, and if slight changes to them can improve program cost effectiveness, such information should be presented to program management for appropriate action.

50.2.1.1.1 Both quantitative and qualitative analyses are useful in determining where reliability resources should be applied. For example, modeling (50.2.2.1), apportionments (50.2.2.2) and estimates (50.2.2.3) of basic reliability and mission reliability, using as inputs available data modified to reflect change in environments and usage, can scope the improvement which may be required. A FMECA (50.2.3.1) based on available mission rules and system definition, not only can provide the framework for the estimate, but also can be used to determine compliance with failure tolerance criteria and to identify single failure points which are critical to either mission success or safety, or both.

50.2.1.1.2 These kinds of analyses identify improvements which must be made if requirements are to be met. Some techniques which have been used to assure efficient use of available resources in meeting the identified needs are presented in the following paragraphs.

50.2.1.2 Analyses as work direction tools. Reliability analyses are efficient work direction tools, because they can confirm system adequacy or identify the need for design change, providing they are accomplished in conjunction with or reviewed by other disciplines.

50.2.1.3 Analysis applicability. The use of reliability analyses is not limited to the phase traditionally thought of as the design phase. Some of the analyses mentioned above, and expanded upon in 50.2.2 and 50.2.4, are useful during the early acquisition phases when design criteria, mission requirements, and preliminary designs are being developed. Since the situation is generally fluid during these phases and firm commitments for full scale development have not yet been made, a comparison of the reliability benefits of competing configuration concepts may be more readily accepted for use in the decision making process. Basically, the ultimate reliability that can be attained by any system, subsystem, or item is limited by the configuration chosen. Therefore, the analyses should be selected to aid in configuration definition in light of the existing design criteria and mission requirements. Preliminary reliability estimates (50.2.2.3) and FMECA (50.2.3.1) are generally the most appropriate for this purpose. The depth of the estimates should be sufficient for comparison of the configurations.

50.2.1.3.1 The cost of the selected analyses is obviously a function of both the level and breadth requested. For example, an FMECA at the part level for all equipment in a weapons system is time consuming, and action taken to reduce reliability risk as a result of such an analysis will probably not be cost effective (usually the failure of every part is critical to equipment operation). However, when the analysis is conducted at the "black box" or similar level, single point failures can be identified and the need for a more detailed analysis or design action can be determined. Similar considerations (which are largely subjective) should be used in tailoring other analyses to fit program needs. The cardinal principles are:

> FOR BASIC RELIABILITY, DO NOT ANALYSE BELOW THE LEVEL AT WHICH A FAILURE WILL CAUSE A DEMAND FOR MAINTENANCE, REPAIR, OR LOGISTICS SUPPORT.
> FOR MISSION RELIABILITY, DO NOT ANALYZE BELOW THE LEVEL NECESSARY TO IDENTIFY MISSION CRITICAL FAILURES.

50.2.2 Models, allocations, and predictions

50.2.2.1 Reliability model (task 201). A reliability model of the system/subsystem/equipment is required for making numerical apportionments and estimates; it is mandatory for evaluating complex series-parallel equipment arrangements which usually exist in weapons systems. In every case the rationale behind the reliability model should be documented. A model should be developed whenever a failure tolerant design is being analyzed.

50.2.2.1.1 The basic information for the reliability model is derived from the functional (schematic) block diagrams. The diagrams depict functional relationships of subsystems and components available to provide the required performance. The reliability model reorients the diagrams into a series-parallel network showing reliability relationships among the various subsystems and components. (The authenticity of the functional relationships depicted by the diagrams should be checked by a failure modes, effects, and criticality analysis.)

50.2.2.1.2 The model should be developed as soon as program definition permits, even though usable numerical input data are not available. Careful review of even the early models can reveal conditions where management action may be required. For example, single point failure conditions which can cause premature mission termination or unacceptable hazards can be identified for further consideration.

50.2.2.1.3 The model should be continually expanded to the detail level for which planning, mission, and system definition are firm. The expansion need not be to the same level for all functions until design definition is complete. In the interim, more detail should be added to the model as it becomes available so that evaluations may proceed apace with program decisions.

50.2.2.1.4 Together with duty cycle and mission duration information, the model is used to develop mathematical expressions or computer programs which, with appropriate failure rate and probability of success data, can provide apportionments, estimates, and assessments of basic reliability and mission reliability.

50.2.2.2 Tops down allocations (task 202). System reliability requirements can evolve in a number of ways from informed judgments to analyses based on empirical data. Ideally, the requirements are such that the total cost of developing, procuring, operating, and maintaining the system over its life is minimized.

50.2.2.2.1 Once quantitative system requirements have been determined, they are allocated or apportioned to its subsystems. A number of schemes can be used, but the objective is common--to transform the system requirement into manageable lower level requirements. Even though the initial allocations may be gross, they can nevertheless indicate to managers the scope of the resources required for the reliability program.

50.2.2.2.2 Before resources can be specifically allocated for achieving subsystem requirements, however, the specific subsystem requirements must be refined. A useful technique in the refinement process is to allot some failure probability to a reserve for each subsystem. This technique recognizes that new functions will be added and thereby precludes the need for continual reallocation to accommodate additional design definitions. Included in this process should be a comparison of the merging requirements with empirical data for identical or similar hardware, to determine the realism of the allocation in terms of reasonable expectation. If some of the requirements appear to be unreasonably difficult to achieve, then the analysis becomes the basis for performing design tradeoffs among the subsystems to reallocate the system requirement. This total process--gross allocations, comparisons with empirical data, tradeoffs, reiterating as required-- eventually results in subsystem requirements. Then, with this information, the amount of effort and personnel resources required can be estimated and programmed.

50.2.2.2.3 The allocation process should be initiated as soon as possible in the early acquisition phases, for it is then that most flexibility in tradeoffs and redefinition exists. Another reason for starting early is to allow time to establish lower level reliability requirements (system requirement allocated to subsystems, subsystem requirement allocated to assemblies, et cetera). Also, the requirements must be frozen at some point to establish baseline requirements for designers.

50.2.2.2.4 After the lower level reliability requirements are defined, they should be levied on the responsible equipment engineers (contractor and subcontractor) for all hardware levels. Without specific reliability requirements which must be designed to or achieved, reliability becomes a vague and undefined general objective for which nobody is responsible. From another perspective, program progress can be measured by evaluating defined reliability requirements at a given milestone/time period with what has actually been accomplished.

50.2.2.2.5 The reliability requirements produced from allocations should be the basis for essential inputs to other related activities. Maintainability, safety, quality engineering, logistics, and test planning are examples of activities whose work will be facilitated with established reliability requirements.

50.2.2.3 Reliability predictions (task 203)

50.2.2.3.1 General criteria. Allocations are determined from the system reliability requirements to provide lower level requirements which are levied on the equipment designers (50.2.2.2). As design work progresses, predictions, based on previously generated data, and assessments based on program test data, are the tools used to indicate whether the allocated requirement can or will be met. However, predictions should not be used as a basis for determining attainment of reliability requirements. Attainment of requirements will be based on representative test results.

50.2.2.3.1.1 Predictions combine lower level reliability data to indicate equipment reliability at successively higher levels from subassemblies through subsystems to the system. Predictions falling short of requirements at any level signal the need for management and technical attention. A shortfall in basic reliability, for example, may be offset by simplifying the design, by use of higher quality parts, or by trading off detailed performance tolerances. In addition, a shortfall in mission reliability may be offset by the use of redundancy or alternative modes of operation (it should be noted that such design techniques increase system complexity, reduce basic reliability, and increase life cycle cost). Alternatively, shortfalls may dictate the need to reaccomplish the reliability allocation and to redefine requirements which can reasonably be achieved at the lower equipment levels.

50.2.2.3.1.2 The prediction task, iterative and interrelated with activities such as reliability allocation and configuration analyses (50.2.3), should be specified by the procuring activity during the early acquisition phases to determine reliability feasibility, and during the development and production phases to determine reliability attainability. Predictions provide engineers and management essential information for day-to-day activities; in addition, they are important supporting elements for program decision-makers.

50.2.2.3.2 Predictions should be made as early as possible and updated whenever changes occur. While early predictions based on parts counts are inherently unrefined because of insufficient design detail, they provide useful feedback to designers and management on the feasibility of meeting the basic reliability requirements. As the design progresses, and hardware relationships become better defined, the model of the system depicting relationships between basic reliablity and mission reliability should be exercised to provide predictions up through the system level.

50.2.2.3.3 As a system progresses from paper design to hardware stages, predictions mature as actual program test data become available and are integrated into the calculations. The validity of predictions is a function of data quality and assumptions. Valid, timely analyses projecting or indicating deficient reliability attainment provide the basis for corrective action, and the sooner that corrective action is identified, the less its implementation is impacted by program constraints, and the higher are the payoffs over the life of the system. The reliability values produced from predictions should be the basis for essential inputs to other related activites. Maintainability, safety, quality engineering, logistics, and test planning are examples of activities whose work will be facilitated with established reliability requirements.

50.2.2.3.3.1 Equipment predictions based on part failure rates. Equipment level predictions using part failure rates: (1) provide a basis for identifying design, part selection/application and environmental problem areas, (2) provide early indication of capability to meet the reliability test requirement, and (3) are essential inputs to system/subsystem level predictions(50.2.2.3.3).

50.2.2.3.3.1.1 Reliability predictions should be accomplished at the lowest equipment level that the preliminary design and configuration analyses permit. For off-the-shelf hardware to be incorporated into a higher level assembly, a prediction can be an empirical data assessment adjusted for new or different mission requirements. For newly-designed equipment, analytical derivation of failure rates for constituent components may have to suffice until actual data can be acquired. Electronic part failure rate prediction techniques are available in the current edition of MIL-HDBK-217. Techniques for predicting failure rates for mechanical and electromechanical devices, however, are not so readily available and therefore dialogue between reliability and design engineers is important to ensure that mission and environmental impacts on device performance are accounted for in the failure rates. In either the electronic or the nonelectronic cases, the part or component failure rates are the basic building blocks for accomplishing higher level predictions.

50.2.2.3.3.1.2 The fundamental reason for early predictions based on parts failure rates is to precipitate appropriate action during development, when it is most tolerable from a program standpoint and most effective from the basic reliability and mission reliability viewpoints. Early review of reliability predictions at lowest equipment levels can identify parts or components which have inadequate margins between parts strength and expected applied stress. In addition, the earlier the review is performed, generally the greater is the range of acceptable options for improving the predictions and the equipment. Whenever predictions fall short of allocated reliability requirements, alternatives such as the following should be considered: identify suitable substitutes, reaccomplish reliability allocations, improve selected parts/components, redesign, modify the mission to decrease severity of environments or other factors. Some alternatives are more feasible and acceptable than others at given points in development, but all are easier and less expensive to accomplish earlier than later.

50.2.2.3.3.1.3 Reliability predictions at any equipment level become inputs to higher level predictions. Prediction quality at all levels depends on how well the reliablity model used represents the hardware and its functional relationships. The better the predictions, in terms of reduced uncertainty, the more justifiable are the reliability and design decisions resulting therefrom--whether the decision is to maintain the status quo or to take action to improve hardware reliability.

50.2.2.3.3.1.4 A serial model prediction of basic reliability must be made for every system, subsystem, and equipment, whether or not it includes any redundancy, to provide estimates as input for maintenance and logistics support plans, ownership cost estimates, and life cycle cost estimates.

50.2.3 <u>Configuration analyses</u>

50.2.3.1 <u>Failure modes, effects, and criticality analysis (FMECA) (task 204).</u> A FMECA is a powerful tool to optimize the performance/life cycle cost tradeoff between mission reliability and basic reliability at the black box/component or major subsystem level, where these tradeoffs are most appropriately analyzed and evaluated. Potential design weaknesses are identified through the use of engineering schematics and mission rules to systematically identify the likely modes of failure, the possible effects of each failure (which may be different for each life/mission profile phase), and the criticality of each effect on safety, readiness, mission success, demand for maintenance/logistics support, or some other outcome of significance. A reliability criticality number may be assigned to each failure mode, usually based on failure effect, severity, and probability of occurrence. These numbers are sometimes used to establish corrective action priorities, but because of the subjective judgment required to establish them, they should be used only as indicators of relative priorities. FMECA can also be used to confirm that new failure modes have not been introduced in transforming schematics into production drawings.

50.2.3.1.1 The initial FMECA can be done early in the CONCEPT phase, and because only limited design definition may be available, only the more obvious failure modes may be identified. It will, however, identify many of the single failure points, some of which can be eliminated by a schematic rearrangement. As greater mission and design definitions are developed in VALID and FSED phases, the analysis can be expanded to successively more detailed levels and ultimately, if required, to the part level. Additionally, for non-detectable failures, the analysis should be carried further to determine the effect of a second failure (e.g., double-point failure). Where non-detectable failures cannot be eliminated, scheduled maintenance procedures may have to be modified to minimize their probability of occurrence. Non-detectable failures (e.g., check valves, weight-on-wheels switches, et cetera) are often overlooked by analysis and the FMECA should be carried out far enough to consider the overall effect on the total system. With regard to one-shot systems, it may be particularly desirable to analyze manufacturing documentation such as circuit board layouts, wire routings and connector keying to determine if new failure modes have been introduced that were not in circuit schematics.

50.2.3.1.2 The usefulness of the FMECA is dependent on the skill of the analyst, the available data, and the information he provides as result of the analysis. The FMECA format may require additional information such as, failure indication, anticipated environment under which the failure may be expected to occur, time available for operational corrective action, and the corrective action required. The requirement to supply such additional information should in general be limited to those potential failures which imperil the crew or preclude mission completion. FMECA results may suggest areas where the judicious use of redundancy can significantly improve mission reliability without unacceptable impact on basic reliability, and where other analyses, e.g., electronic parts tolerance analyses, should be made or other provisions, such as environmental protections, should be considered. Additionally, FMECA results can be used to provide the rationale for the details of operating procedures used to ameliorate undesirable failure modes and to document the residual risk. FMECA is also an effective tool for evaluating the effectiveness of built-in-test.

50.2.3.1.3 Finally, FMECA results should be used to confirm the validity of the model (50.2.2.1) used in computing estimates for subsystems or functional equipment groupings, particularly where some form of redundancy is included. The identity of reliability critical items (50.2.4.3) which are a part of the selected configurations should be retained and included in the RFP for the development phase. These items are the prime candidates for detailed analysis, growth testing, reliability qualification testing, reliability stress analyses and other techniques to reduce the reliability risk. It is advisable to request the respondents to examine the list of reliability critical items and make appropriate recommendations for additions and deletions with supporting rationale. FMECA results should be used in defining test and checkout procedures to assure all essential parameters, functions, and modes are verified.

50.2.3.1.4 Because of the many and varied skills required to determine failure modes, effects, corrective action, etc., the FMECA requires inputs from many disciplines. For this reason, it is relatively unimportant which engineering group is selected to make the analysis. What is important is the critical examination of the results by all disciplines which could have useful knowledge that can be brought to bear on the analysis. The analysis is most effective when made as the design progresses, i.e., it is a working tool. It is therefore more cost effective to review the analysis prior to formal publication and at scheduled Program Reviews.

50.2.3.2 Sneak circuit analysis (SCA) (task 205). A SCA is based on the use of engineering and manufacturing documentation. Its purpose is to identify latent paths which cause occurrence of unwanted functions or inhibit desired functions, assuming all components are functioning properly. SCA of electro-mechanical circuits is a useful technique that can also be used for discrete analog and digital circuitry. Finally, the analysis should be considered for critical systems and functions where other techniques are not effective, but should not be applied to off-the-shelf computer hardware such as memory or data processing equipment.

50.2.3.2.1 SCA is a useful engineering tool which can be used to identify sneak circuits, drawing errors and design concerns. The effects of varying environments are not normally considered, and sneak circuits which result from hardware failure, malfunction, or environmentally sensitive characteristics are not usually identified. The identification of a sneak circuit does not always indicate an undesirable condition; in fact, some have been used to accomplish tasks when other circuitry has failed. The implications of a sneak circuit, therefore, must be explored and its impact on the circuit function determined before any action is taken.

50.2.3.2.2 SCA may be expensive. It is usually performed late in the design cycle after the design documentation is complete which makes change difficult and costly to implement, and it is not defined as a technique by any MIL-STD. Therefore, SCA should be considered only for components and circuitry which are critical to mission success and safety. Cost may rule out the use of SCA for digital logic circuits because it is necessary to consider all combinations of switching positions, transients, and timing which could require considerable computer time.

50.2.3.3 Electronic parts/circuits tolerance analysis (task 206). Because of within-specification part tolerance buildup, an output from a circuit, subassembly, or equipment may be outside spec values and therefore unacceptable. In such cases, fault isolation will not identify any part as failed or input as unacceptable. To preclude the existence of this condition, a parts/circuits tolerance analysis is conducted. This analysis examines, at component interconnections and input and output points, the effects of parts/circuits electrical tolerances and parasitic parameters over the range of specified operating temperatures. This analysis has proven cost effective in identifying equipment performance/reliability problem areas so they can be corrected prior to production.

50.2.3.3.1 The analysis considers expected component value variations due to manufacturing variances (purchased tolerances), drift with time (life-drift), and temperature. Some of the characteristics examined are relay opening and closing times, transistor gain, resistance, inductance, capacitance, and component parasitic parameters. Maximum within-spec input signal or power voltage, phase, frequency, and bandwidth; impedance of both signal and load should also be considered. Circuit mode parameters, such as voltage, current, phase, and waveform, can be analyzed for their effect on circuit component performance. Finally, under worst case conditions, the timing of sequential events, circuit load impedance, power dissipation and element rise time should be considered.

50.2.3.3.2 In making this analysis, equivalent circuits and mode-matrix analysis techniques are used to prove that the circuit/equipment will meet specification requirements under all required conditions. The use of a computer is recommended to solve the matrix problem inherent in mode matrix analysis of complex circuitry.

50.2.3.3.3 This analysis is considered to be relatively expensive because of the skill levels required and the time-consuming job of preparing the input information for the computer (use of a computer is mandatory in most cases). For this reason, its application should probably be limited to critical circuitry. For the purpose of this analysis, power circuitry, e.g., power supplies and servo drivers, are usually critical, as to a lesser extent are lower power circuits, such as intermediate frequency strips. Because of the difficulty in specifying precisely the variables to be considered and their ranges, it may be more efficient to specify a parts/circuits analysis of critical circuitry, to require the supplier to identify the circuitry, the variables to be considered, and the statistical limit criteria to be used in evaluating circuit/system performance; and to propose his effort on that basis. Subsequent negotiation prior to procuring the analysis should result in a tailored task that is mutually satisfactory.

50.2.4 Design criteria

50.2.4.1 Failure tolerant design criteria improve mission reliability. A system which can tolerate failures and still successfully complete a mission has a higher MCSP than one which must abort following a failure. System, subsystem, or equipment designs which have this attribute are sometimes called "failure tolerant". Statements which establish the specifics of such tolerance are called "failure tolerance criteria".

50.2.4.1.1 These criteria provide standards for design compliance, and shape subsystem architecture. They are usually found in several places in weapon system and subsystem specifications. Typical of such criteria is the following: "A single failure in any subsystem shall not cause or require a mission abort, and during an abort the single malfunction or failure of a subsystem or component shall not cause loss of the crew." Criteria such as these influence the design and operation of almost all subsystems, and therefore an organized approach is required to meet them. The compliance attained by this approach will use a minimum of added redundancy and complexity. It must be realized that failure tolerant design techniques usually increase complexity and total number of parts; reduce basic reliability (MTBF), maintenance-related reliability (MTBMA), and logistics-related reliablity (MTBR); and thus usually increase both acquisition cost and cost of ownership.

50.2.4.1.2 Compliance with the mission success criteria can best be determined by examining functional diagrams, systems schematics, and software specifications and documentation in the light of mission rules and requirements. Particular attention should be paid to providing power from different sources (where feasible) to redundant or alternative means of accomplishing a function. Besides different power sources, consideration should also be given to the use of different connectors/wiring pins, physical separation/orientation, and different software for redundant equipments. More generally, careful scrutiny is required to identify and avoid arrangements which can invalidate the functional redundancy provided.

50.2.4.1.3 This process of confirming compliance with criteria should be continued through FSED and iterated as dictated by proposed changes during production.

50.2.4.2 Parts selection/application criteria (task 207). Conducting an aggressive parts control and application program increases the probability of achieving and maintaining inherent equipment reliability, minimizes parts proliferation, logistics support costs, and system life cycle costs. The added investment required for a vigorous program which controls parts selection and application can be offset by reduced system life cycle costs for repairable systems and by overall system effectiveness for nonreparable systems. In some cases the use of higher quality parts can even lower item acquisition cost through reduction in the amount of assembly line rework as well as eliminate additional costs for drawings and test data required when using nonstandard parts.

50.2.4.2.1 Parts and components are the basic items comprising higher level assemblies, which in turn ultimately constitute the system, where the "system" may be a radio, a space satellite, or a nuclear submarine. Significant contributions toward system optimization can be realized by applying attention and resources to parts application, selection, and control starting early in VALID phase and continuing throughout the life of the system.

50.2.4.2.2 The decisions as to the depth and extent of the parts program designed for a particular item acquisition should be made based on considerations of factors such as: mission criticality, parts essentiality (to successful mission completion and reduced frequency of maintenance), maintenance concept, production quantity, parts availability, amount/degree of new design, and parts standardization status. A comprehensive parts program can be just as essential for a relatively simple device (e.g., UHF radio) with a large projected inventory as for a single, complex device (e.g., special purpose space system).

50.2.4.2.3 A comprehensive parts program will consist of the following elements:

a. A parts control program (in accordance with MIL-STD-965)

b. Parts standardization

c. Parts application (derating) guidelines established by the contractor

d. Parts testing, screening, or validation

e. GIDEP participation as applicable (MIL-STD-1556)

If such a program is embarked upon, it is imperative that both procuring activity and the contractor assign qualified personnel, because the dynamic nature of parts and component technology can quickly render existing knowledge and experience obsolete. Guidelines for selecting procedure I or II of MIL-STD-965 for parts control are contained in that document.

50.2.4.2.4 The procuring activity should provide general parts application guidelines (e.g. MIL-P-11268(ARMY), MIL-E-5400) for the producer to use in establishing the parts application criteria. These criteria are the standards established and enforced by the contractor for equipment designers (contractor and subcontractor), and should be adhered to because failure rates can increase dramatically (i.e., reliability decreases) with exposure to increased stress levels. Deviations to the parts application criteria should be granted through the parts control program only after evaluating the actual part stress conditions, design alternatives, and impact on circuit and overall system reliability.

50.2.4.2.5 The basic objective of a procuring activity's parts program is to control the selection and use of standard and nonstandard parts. Occasionally--sometimes often, depending on the system--it becomes necessary for the contractor to propose the use of a nonstandard part. Proposals for use of nonstandard parts should be made and accepted only after other options which use standard parts have been investigated. (The parts control activity, besides ruling on the immediate application, should normally make a judgment on whether the part in question meets enough of the criteria to make it a standard part.) Use of standard parts is important because it avoids introducing additional parts into the DoD inventory, it tends to assure a supply of parts throughout the system's life, and can limit tendencies to overdesign or "gold-plate." It is important to also recognize the potential for systems unreliability and increased maintenance contributed by interconnecting wiring and common hardware (e.g., relays, switches, connectors) purchased under separate contract.

50.2.4.2.6 Parts programs should be initiated early in design and continued throughout the life of the system. But, before the beginning of FSED, the procuring activity should clearly spell out an order of preference of part quality levels for use in the system. In addition, the procuring activity should identify prohibited part types. For certain applications, special tests of standard parts may have to be used to obtain acceptable parts which are then unique and must so be identified. It is most important to emphasize, however, that special testing, identification, and selection inhibits standardization, since those processes produce a nonstandard part which may not be readily available to support the system throughout its life.

50.2.4.2.7 Parts program activities are interrelated with all other analyses described in this document, and with analyses performed by other disciplines such as safety, quality engineering, maintainability, survivability and vulnerability. Any of these analyses can indicate the need for different parts: upgraded or unique, in some cases, to meet system requirements; standard or readily available parts, in other cases, to minimize system life cycle costs and ensure supportability.

50.2.4.2.8 An effective parts program requires that knowledgeable parts engineers be used by both the procuring activity and the contractor. Government agencies such as the Defense Industrial Supply Center, the Defense Electronics Supply Center, and the Rome Air Development Center can provide excellent support. Logisticians should always be consulted for their inputs, because they will be required to support the system operationally. The investment in parts programs generally pays handsome dividends in terms of reduced operational costs and improved system operational effectiveness.

50.2.4.3 Reliability critical items (task 208). Reliability critical items are those items whose failure can significantly affect system safety, availability, mission success, or total maintenance/logistics support cost. Critical items shall include, but not be limited to those identified by reliability analysis and FMECA. High-value items should always be considered reliability critical for life cycle cost. A single point failure identified as a mission-critical item, and any design redundancy or alternative modes of operation proposed as a means of eliminating that single point failure, must both be considered in light of their affects on both operational effectiveness and life cycle cost. In other words, redundancy may be necessary, but it must be justified in terms of what it will cost, and what it will buy, over the entire life cycle of the systems inventory.

50.2.4.3.1 Reliability critical items, once identified as a part of the selected configurations, should be retained and included in the RFP for subsequent phases. These items are the prime candidates for detailed analysis, growth testing, reliability qualification testing, reliability stress analyses, and other techniques to reduce the reliability risk. It is advisable to request the respondents to examine the list of reliability critical items and make appropriate recommendations for additions and deletions with supporting rationale.

50.2.4.4 Life criteria (task 209). Planned storage and/or useful life are important considerations for every system, subsystem or component. To gain some assurance that these items can successfully tolerate foreseeable operational and storage influences, it may be advisable to conduct analyses and tests to determine the effects on them of packaging, transportation, handling, storage, repeated exposure to functional testing, et cetera. The information from these analyses and tests can support trade-offs to influence design criteria. This task contains a suggested description of the effort. It is recommended that this task be applied after consulting with cognizant equipment engineers and quality assurance, test and logistics experts.

50.3 Task section 300 - Development and production testing

50.3.1 General considerations

50.3.1.1 Reliability testing. The reliability test program must serve three objectives in the following priority: (1) disclose deficiencies in item design, materiel and workmanship; (2) provide measured reliability data as input for estimates of operational readiness, mission success, maintenance manpower cost, and logistics support cost; and (3) determine compliance with quantitative reliability requirements. Cost and schedule investment in reliability testing shall conform to these priorities to ensure that the overall reliability program is both effective and efficient. Four types of reliability testing are contained in task section 300; ESS, RDGT, RQT and PRAT. Environmental stress screening (ESS, task 301) and reliability development/growth testing (RDGT, task 302) are reliability engineering tests. Program plans shall emphasize early investment in ESS and RDGT to avoid subsequent costs and schedule delays. Reliability qualification tests (RQT, task 303) and production reliability acceptance tests (PRAT, task 304) are reliability accounting tests. They shall be tailored for effectiveness and efficiency (maximum return on cost and schedule investment) in terms of the management information they provide. A properly balanced reliability program will emphasize ESS And RDGT, and limit, but not eliminate, RQT and PRAT.

50.3.1.2 Integrated testing. It is DOD policy that performance, reliability, and environmental stress testing shall be combined, and that environmental stress types shall be combined insofar as practical. It is the responsibility of the PA to draw these tests together into an integrated, effective, and efficient test program. For example, mechanical, hydraulic, pneumatic, and electrical equipment are usually subjected to three qualification tests; performance, environmental, and endurance (durability). The integration of these separate tests into a more comprehensive reliability test program can avoid costly duplication and ensure that deficiencies are not overlooked as they often are in the fragmented approach.

50.3.1.2.1 Performance tests should be conducted as soon as items are fabricated. They should be brief, and should provide the immediate basis for correction of any deficiencies they disclose. However, an item that has passed its performance test must not be considered compliant with Government requirements until it has shown that it will perform reliably under realistic conditions.

50.3.1.2.2 Environmental tests such as those described in MIL-STD-810 should be considered an early portion of RDGT. They must be conducted early in development, to ensure that time and resources are available to correct the deficiencies they disclose, and the corrections must be verified under stress. Such information must be included in the FRACAS (50.1.2.3) as an integral aspect of the reliability program.

50.3.1.2.3 Endurance (durability) testing usuallly consists of a normal test, an overload test, and a mission profile cycling test that duplicates or approximates the conditions expected in service. Failures must be evaluated, and corrective actions must be incorporated in the test items. The test must then be rerun or, at the option of the PA, the test may be completed and an additional run conducted to show the problems have been corrected. This information must also be included in the FRACAS. An integrated test program will combine reliability testing and durability testing.

50.3.1.3 Test realism. A test is realistic to the degree that test conditions and procedures simulate the operational life/mission/environmental profile of a production item. Realistic testing can disclose deficiencies and defects that otherwise would be discovered only after an item is deployed, and it can reduce the disparity between laboratory and operational reliability values. Therefore, test realism must be a primary consideration in every reliability test. A test that only discloses a small fraction of the operational failures it is supposed to disclose is a waste of time and resources. Conversely, a test that induces failures which will not occur in service forces unnecessary expenditures of time and resources to correct those failures. And finally, the degree to which any reliability test must simulate field service depends on the purpose of the test.

50.3.1.3.1 Low test realism is often due to omission of a relevant stress, or incomplete definition of a type of stress. For example, failures that are caused by vibrations are seldom found by tests that apply no vibration, or by tests that ignore the relevant combinations of vibration frequency, amplitude and duration of exposure. Establishment of realistic test conditions and procedures requires a knowledge of the life profile from factory to final expenditure, to include the micro-environments an item will experience during each phase of its life profile, based on measurement of the actual stresses experienced by similar items.

50.3.1.3.2 It is appropriate to apply stress levels greater than those expected in service, if the purpose of the test is to disclose deficiencies, and if test conditions do not induce failures that will not occur in service. On the other hand, both overstress and understress make reliability estimates inaccurate and distort test results used to determine compliance. Therefore, overstress (and step-stress) testing may be applied during ESS and the early portion of RDGT, but the final portion of RDGT, and both RQT and PRAT, should simulate the operational life profile insofar as practical and cost-effective.

50.3.1.3.3 Precise simulation of the operational life profile would expose each item and each part of each item to the exact stress types, levels and durations they will experience in service. Such idealistic testing is seldom practical or cost-effective. Some stress types cannot be combined in the same test facility, and some may cost more to reproduce in the laboratory than they are worth in terms of the failures they cause in service. Stress types may be applied in series for ESS and the early portion of PRAT. Total test time may be compressed by reducing the amount of time spent in simulating less stressful phases of the life profile. (Note that overstress is a valid way to accelerate the discovery of deficiencies and defects, but it is not a valid means of compressing test time when reliability is to be measured.) MIL-STD-781 contains guidance for realistic combined-stress, life/mission profile reliability testing.

50.3.1.4 Reliablity estimates and projections. Measured reliability data must serve a variety of needs for management information, in addition to its use as a basis for determining compliance with quantitative reliability requirements. Point (and interval) estimates of the demonstrated reliability are essential inputs for operations and support plans, manning and sparing decisions, ownership cost and life cycle cost estimates. It is imperative that these inputs be defined in the appropriate units of measurement and based on realistic test results. MIL-STD-781 contains guidance for confidence interval estimates of the demonstrated MTBF. The PA may translate demonstrated MTBF into the proper units of measurement for system reliability parameters, or require the contractor to perform these translations.

50.3.1.4.1 In cases where it is impractical or inefficient to demonstrate all applicable system reliability parameters at the system level of assembly, system level estimates must be compiled from lower level test results. Audit trails are required to relate basic reliability measurements (MTBF) with the proper units of measurement for each system reliability parameter (such as MCSP and MTBMA), and to account for elements of operational reliability values which are not simulated during the test (such as the influence of operation and support concepts, policies and planning factors). The PA may specify each element of these audit trails, or require that audit trails be developed subject to PA approval.

50.3.1.4.2 Reliability values measured during ESS and the early portion of RDGT cannot be expected to correlate with reliability values in service. Reliability values measured during the final portion of RDGT, and both RQT and PRAT, must be correlated with reliability values in service, by optimum test realism and clear traceabilty between test and field measurements. All relevant test data must be used to project operational reliability for estimates of operational effectiveness (readiness and mission success) and ownership cost (maintenance manpower costs and logistic support cost). Only chargeable test results shall be used to determine contractual compliance with quantitative reliability requirements.

50.3.1.5 Relevant failures and chargeable failures. Failure and relevant failure are defined by DOD policy. A failure is the event in which any part of an item does not perform as required by its performance specification. A relevant failure is one that can occur or recur during the opeational life of an item inventory. Therefore, there are only two types of nonrelevant failure; (1) those verified as caused by a condition not present in the operational environment, and (2) those verified as peculiar to an item design that will not enter operational inventory. A chargeable failure is relevant failure caused by any factor within the responsibility of a given organizational entity, whether Government or commercial. Every relevant failure shall be charged to somebody. For example, relevant failures due to software errors are chargeable to the software supplier; those caused by human errors are chargeable to the employer, or to the agency responsible for training. Dependent failures are chargeable, as one independent failure, to the supplier of the item that caused them, whether that item is GFE or CFE. In keeping with DOD policy that responsibilities must be cearly defined, chargeability refers to the responsibility for; (1) the cause of failure, and (2) corrective action to prevent recurrence of failure.

50.3.1.6 Statistical test plans. The statistical design of any reliability test depends on the purpose of that test. ESS and RDGT must not include accept/reject criteria that penalizes the contractor in proportion to the number of failures he finds, because that would be contrary to the purpose of the test; so these tests must not use statistical test plans that establish such criteria. RQT and PRAT must provide a clearly defined basis for determining compliance, but they must also be tailored for effectiveness and efficiency (maximum return on cost and schedule investment) in terms of the management information they provide. Therefore, selection of any statistical test plan for RQT or PRAT shall be based on the amount of confidence gained (the degree that confidence intervals are reduced) by each additional increment of testing. For example, a test that stops at the first failure leaves a wide range of uncertainty; testing to the fifth or sixth failure dramatically reduces that uncertainty; but testing beyond the eighth or ninth failure buys very little in terms of increased confidence or reduced risk. Finally, specified confidence levels, discrimination ratios, and decision risks shall be subject to tradeoffs with total test time and cost, to include impact cost of program schedule delay.

50.3.1.6.1 Probability ratio sequential test (PRST) plans are only intended to determine compliance (accept or reject) on the basis of predetermined decision risks. They are not intended to provide estimates of demonstrated reliability, and they leave no decisions to the PA once they have been specified. PRST plans contain significant uncertainties in regard to actual test time. Therefore, if program cost and schedule are based on the "expected decision point", rather than the "maximum allowable test time", specification of a PRST will build in potential cost and schedule overruns that the PA cannot control. In general, PRST plans may be used for PRAT, if only a simple "accept or reject" decision is desired and if schedule uncertainty is not a major concern, but they should not be used for RQT.

50.3.1.6.2 Fixed-length test plans should be specified when actual test time must be subject to PA control, and when something more than a simple "accept or reject" decision is desired. For example, the PA may wish to specify a fixed-length test, assess the data as it becomes available, and make an early accept decision on the basis of measured test results to date. (Reject decisions based on real-time data assessment are not recommended, because they may require changes in the contract.) Fixed-length test plans may also provide a basis for structuring incentive fees. For example, the contract may state that base price will be paid for those items having a demonstrated reliability (point estimate) within a specified range; that an incentive fee will be paid for reliability above that range; that penalty or remedy will be required for reliability below that range, and that items having demonstrated reliability below a minimum acceptable (observed) value will not be purchased by the government. These provisions may also apply to production lots.

50.3.1.7 Independent testing. It is DOD policy that, insofar as possible, test which determine compliance with reliability requirements shall be conducted or controlled by someone other than the supplier whose compliance is being determined. The PA is responsible for implementation of this policy. It applies to RQT and PRAT, but it does not apply to ESS or RDGT. The PA may elect to have RQT and PRAT conducted under separate contract to a government or commercial test facility. A higher tier contractor may be required to conduct or control these tests on behalf of the government. The supplier's test facility may be used by sending in a team of independent test engineers for the duration of the test. The supplier must be invited to witness all independent RQT or PRAT of his product, and test results must be fed back to the supplier (such feedback provides incentive for his quality control program). Exceptions in which the supplier conducts RQT or PRAT of his own product may be granted only in situations of technical or financial necessity.

50.3.1.8 Testing compliance. The contractor is compliant with specified ESS (task 301) requirements when testing has been performed as specified in the contract, failures have been corrected, and corrections have been verified.

The contractor shall be held responsible for the achievement of specified reliability growth during RDGT (task 302). The contract should specify accelerated effort in event of failure to meet reliability growth targeted on the specified values (goals), and noncompliance provisions in accordance with the Defense Acquisition Regulations for failure to meet reliability growth targeted on the minimum acceptable values (thresholds). The contractor is compliant with RQT (task 303) or PRAT (task 304) requirements if an accept decision is reached in accordance with the statistical test plan, or when the PA accepts items on the basis of real-time data assessment. It is imperative that a reject decision denote contractual noncompliance, rather than a potentially endless series of corrective actions and retests; if the PA fails to ensure that contracts reflect this policy, total test item will remain inherently open-ended and quantitative reliability requirements will remain inherently unenforceable.

50.3.1.9 Documentation. An integrated test and evaluation master plan (TEMP) must be prepared by the PA, or prepared subject to PA approval. The TEMP must include each phase of testing, the ground rules for each test, the impact on GFE, and the criteria for successful completion of each test. In addition, a test procedures document is required for each type of reliability test (tasks 301, 302, 303, and 304). These documents describe the item(s) to be tested. the test facilities, the item performance and performance monitoring requirements, data handling, and location of test instrumentation. The TEMP and the test procedures documents should be delivered to the PA early enough to allow PA review and approval (normally 60 days) before the start of testing. Once testing is underway, the approved TEMP and the test procedures documents must be used to monitor and control conduct of the tests. Information on failures must be compared with existing information in the FRACAS. Accurate record-keeping, with proper failure analysis and corrective action, will provide the insight needed to manage specified reliability growth (ESS And RDGT), and will point out the need for any corrective actions late in the program (RQT and PRAT). Even though most failures should have been corrected before the start of RQT, latent deficiencies and defects must be corrected as soon as possible after they are discovered. Delay only compounds the problem and the cost of correction.

50.3.2 Reliability engineering tets

50.3.2.1 Environmental stress screening (ESS) (task 301). ESS is a test, or a series of tests, specifically designed to disclose weak parts and workmanship defects for correction. It should be applied to parts, components, subassemblies, assemblies, or equipment (as appropriate and cost-effective), to remove defects which would otherwise cause failures during higher-level testing or early field service. The test conditions and procedures for ESS should be designed to stimulate failures typical of early field service, rather than to provide precise simulation of the operational life profile. Environmental stress types (such as random vibration and thermal cycling) may be applied in series, rather than in combination, and should be tailored for the level of assembly at which they are most cost-effective. ESS testing has significant potential return on investment, for both the contractor and the government, during both development and production. All-equipment ESS (100% sampling) is recommended for PA consideration.

50.3.2.1.1 The PA may specify detailed ESS requirements, or have the contractor develop an ESS test plan subject to PA approval. In either case, the PA should specify a minimum test time per item, a failure-free interval, and a maximum test time per item (after which that item will be considered too worn out by the test to be a deliverable item). The contractor must not be penalized for the number of failures discovered during ESS, but must be required to correct every failure, and to prevent recurrence of failures through use of more reliable parts and the reduction of workmanship errors during the manufacturing process.

50.3.2.1.2 ESS must not be confused with PRAT. ESS employs less expensive test facilities, and is recommended for 100% sampling. PRAT requires a more realistic simulation of the life profile, and more expensive test facilities, and therefore is not recommended for 100% sampling. ESS must be conducted by the contractor, while PRAT must be independent of the contractor if at all possible. Where the statistical test plans for RQT or PRAT are based on the exponential distribution (constant failure rate), ESS is a prerequisite for RQT and PRAT, because those test plans assume that early failres have been eliminated.

50.3.2.2 Reliability development/growth testing (RDGT) (task 302). RDGT is a planned, pre-qualification, test-analyze-and-fix process, in which equipments are tested under actual, simulated, or accelerated environments to disclose design deficiencies and defects. This testing is intended to provide a basis for early incorporation of corrective actions, and verification of their effectiveness, thereby promoting reliability growth. However:

TESTING DOES NOT IMPROVE RELIABILITY. ONLY CORRECTIVE ACTIONS THAT PREVENT THE RECURRENCE OF FAILURES IN THE OPERATIONAL INVENTORY ACTUALLY IMPROVE RELIABILITY.

50.3.2.2.1 It is DOD policy that reliability growth is required during full-scale development, concurrent development and production (where concurrency is approved), and during initial deployment. Predicted reliability growth shall be stated as a series of intermediate milestones, with associated goals and thresholds, for each of those phases. A period of testing shall be scheduled in conjunction with each intermediate milestone. A block of time and resources shall be scheduled for the correction of deficiencies and defects found by each period of testing, to prevent their recurrence in the operational inventory. Administrative delay of reliability engineering change proposals shall be minimized. Approved reliability growth shall be assessed and enforced.

50.3.2.2.2 Predicted reliability growth must differentiate between the apparent growth achieved by screening weak parts and workmanship defects out of the test items, and the step-function growth achieved by design corrections. The apparent growth does not transfer from prototypes to production units; instead, it repeats in every individual item of equipment. The step-function growth does transfer to production units that incorporate effective design corrections. Therefore, RDGT plans should include a series of test periods (apparent growth), and each of the test periods should be followed by a "fix" period (step-function growth). Where two or more items are being tested, their "test" and "fix" periods should be out of phase, so one item is being tested while the other is being fixed.

50.3.2.2.3 RDGT must correct failures that reduce operational effectiveness, and failures that drive maintenance and logistic support cost. Therefore, failures must be prioritized for correction in two separate categories; mission criticality, and cumulative ownership cost criticality. The differences between required values for the system reliability parameters shall be used to concentrate reliability engineering effort where it is needed (for example: enhance mission reliability by correcting mission-critical failures; reduce maintenance manpower cost by correcting any failures that occur frequently).

50.3.2.2.4 It is imperative that RDGT be conducted using one or two of the first full-scale engineering development items available. Delay forces corrective action into the formal configuration control cycle, which then adds even greater delays for administrative processing of reliability engineering changes. The cumulative delays create monumental retrofit problems later in the program, and may prevent the incorporation of necessary design corrections. An appropriate sequence for RDGT would be: (1) ESS to remove defects in the test items and reduce subsequent test time, (2) environmental testing such as that described in MIL-STD-810, and (3) combined-stress, life profile, test-analyze-and-fix. This final portion of RDGT differs from RQT in two ways: RDGT is intended to disclose failures, while RQT is not; and RDGT is conducted by the contractor, while RQT must be independent of the contractor if at all possible.

50.3.3 Reliability accounting tests

50.3.3.1 Reliability qualification test (RQT) (task 303). RQT is intended to provide the government reasonable assurance that minimum acceptable reliability requirements have been met before items are committed to production. RQT must be operationally realistic, and must provide estimates of demonstrated reliability. The statisitical test plan must predefine criteria of compliance ("accept") which limit the probability that true reliability of the item is less than the minimum acceptable reliability requirement, and these criteria must be tailored for cost and schedule efficiency. However:

TESTING TEN ITEMS FOR TEN HOURS EACH IS NOT EQUIVALENT TO TESTING ONE ITEM FOR ONE HUNDRED HOURS, REGARDLESS OF ANY STATISTICAL ASSUMPTIONS TO THE CONTRARY.

50.3.3.1.1 It must be clearly understood that RQT is preproduction test (that is, it must be completed in time to provide management information as input for the production decision). The previous concept that only required "qualification of the first production units" meant that the government committed itself to the production of unqualified equipment.

50.3.3.1.2 Requirements for RQT should be determined by the PA and specified in the request for proposal. RQT is required for items that are newly designed, for items that have undergone major modification, and for items that have not met their allocated reliability requirements for the new system under equal (or more severe) environmental stress. Off-the-shelf (government or commercial) items which have met their allocated reliability requirements for the new system under equal (or more severe) environmental stress may be considered qualified by analogy, but the PA is responsible for ensuring there is a valid basis for that decision.

50.3.3.1.3 Prior to the start of RQT, certain documents should be available for proper conduct and control of the test. These documents include: the approved TEMP and detailed RQT procedures document, a listing of the items to be tested, the item specification, the statistical test plan (50.3.1.6), and a statement of precisely who will conduct this test on behalf of the government (50.3.1.7). The requirements and submittal schedule for these document must be in the CDRL.

50.3.3.2 Production reliability acceptance test (PRAT) (task 304). PRAT is intended to simulate in-service evaluation of the delivered item or production lot. It must be operationally realistic, and may be required to provide estimates of demonstrated reliability. The statistical test plan must predefine criteria of compliance ("accept") which limit the probability that the item tested, and the lot it represents, may have a true reliability less than the minimum acceptable reliability, and these criteria must be tailored for cost and schedule efficiency. PRAT may be required to provide a basis for positive and negative financial feedback to the contractor, in lieu of an in-service warranty (50.3.1.6). Because it must simulate the item life profile and operational environment, PRAT may require rather expensive test facilities; therefore, all-equipment PRAT (100% sampling) is not recommended. Because it must provide a basis for determining contractural compliance, and because it applies to the items actually delivered to operational forces, PRAT must be independent of the supplier if at all possible (50.3.1.7). Finally, even though sampling frequency should be reduced after a production run is well established, the protection that PRAT provides for the government (and the motivation it provides for the contractor's quality control program) should not be discarded by complete waiver of the PRAT requirement.

60. DATA ITEM DESCRIPTIONS (DID)

60.1 The following is a list of data item descriptions associated with the reliability tasks specified herein:

TASK	APPLICABLE DID	DATA REQUIREMENT
101	DI-R-7079	Reliability Program Plan
103	DI-R-7080	Reliability Status Report
104	DI-R-7041	Report, Failure Summary and Analysis
201	DI-R-7081	Reliability Mathematical Model(s)
202	DI-R-2114	Report, Reliability Allocation
203	DI-R-7082	Reliability Predictions Report
204	DI-R-1734	Report, Failure Modes, Effects and Criticality Analysis Report
	DI-R-2115A	Report, Failure Mode and Effect Analysis (FMEA) (DI-R-2115A is to be used only when MIL-STD-1629 has been designated as the basis for MIL-STD-785B, Task 204)
205	DI-R-7083	Sneak Circuit Analysis Report
206	DI-R-7084	Electronic Parts/Circuits Tolerance Analysis Report
208	DI-R-35011	Plan, Critical Item Control

60.2 The following tasks have DIDs associated with them related to imposition of MIL-STD-781C:

301	DI-R-7040	Report, Burn-in Test
302, 303, 304	DI-R-7033	Plan, Reliability Test
303, 304	DI-R-7035	Procedures, Reliablity Test and Demonstration
303, 304	DI-R-7034	Reports, Reliability Test and Demonstration (Final report)

NOTES: (1) Only data items specified in the CDRL are deliverable. Therefore, those data requirements identified in the Reliability Program Plan must also appear in the CDRL.

(2) The PA should review all DID's and assure through tailoring, that the preparation instructions in the DID are compatible with task requirements as specified in the SOW.

INSTRUCTIONS: In a continuing effort to make our standardization documents better, the DoD provides this form for use in submitting comments and suggestions for improvements. All users of military standardization documents are invited to provide suggestions. This form may be detached, folded along the lines indicated, taped along the loose edge *(DO NOT STAPLE)*, and mailed. In block 5, be as specific as possible about particular problem areas such as wording which required interpretation, was too rigid, restrictive, loose, ambiguous, or was incompatible, and give proposed wording changes which would alleviate the problems. Enter in block 6 any remarks not related to a specific paragraph of the document. If block 7 is filled out, an acknowledgement will be mailed to you within 30 days to let you know that your comments were received and are being considered.

NOTE: This form may not be used to request copies of documents, nor to request waivers, deviations, or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

(Fold along this line)

(Fold along this line)

DEPARTMENT OF THE AIR FORCE

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 73236 WASHINGTON D. C.

POSTAGE WILL BE PAID BY THE DEPARTMENT OF THE AIR FORCE

ASD/ENESS
Wright-Patterson AFB, O 45433

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL
(See Instructions – Reverse Side)

1. DOCUMENT NUMBER

2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION

4. TYPE OF ORGANIZATION *(Mark one)*

☐ VENDOR

☐ USER

☐ MANUFACTURER

☐ OTHER *(Specify)*: ______

b. ADDRESS *(Street, City, State, ZIP Code)*

5. PROBLEM AREAS

a. *Paragraph Number and Wording:*

b. *Recommended Wording:*

c. *Reason/Rationale for Recommendation:*

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – *Optional*

b. WORK TELEPHONE NUMBER *(Include Area Code)* – *Optional*

c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – *Optional*

8. DATE OF SUBMISSION *(YYMMDD)*