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## MILITARY STANDARD

# RELIABILITY PROGRAM REQUIREMENTS FOR SPACE AND LAUNCH VEHICLES

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DEPARTMENT OF THE AIR FORCE
Washington, D.C. 20330

MIL-STD-1543B (USAF)

Reliability Program Requirements for Space and Launch Vehicles

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by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

## FOREWORD

The high reliability required of all space and launch vehicles is achieved by the designs, including the design margins, and by the manufacturing processes and controls imposed at every level of fabrication, assembly, and test. The design and design margins should ensure that the equipment is capable of performing in the operational environment. The reliability program requirements stated in this standard have been established to ensure the timely and economical attainment of system reliability as an integral part of the acquisition process. The requirements are a composite of those that have been found to be cost effective on previous space programs.

This standard provides a consistent approach to help achieve, in a cost effective way, the high reliability required for space and launch vehicles. For the convenience of the user of this standard, it is organized similar to MIL-STD-785B, "Reliability Program for Systems and Equipment Development and Production," although this standard is an independent document.

The requirements of this standard complement other typical contract provisions, such as the requirements for quality assurance in MIL-STD-1586, "Quality Program Requirements for Space and Launch Vehicles"; the requirements for a Parts, Materials, and Processes Control Program in MIL-STD-1546, "Parts, Materials, and Processes Standardization, Control, and Management Program for Spacecraft and Launch Vehicles"; and the testing requirements in MIL-STD-1540, "Test Requirements for Space Vehicles."

When preparing their proposal, a contractor may include additional tasks or task modifications. Such added tasks or task modifications should be clearly identified, include supporting rationale, and be independently priced for ease of evaluation. Contractors are always encouraged to report to the contracting officer, for program office review and consideration, those specific requirements that seem inappropriate, are believed excessive, or are conflicting with other contract requirements. However, contractors are reminded that any departure from contractually imposed requirements can be granted only by the contracting officer.

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TABLES

# SECTION 1

# SCOPE

## 1.1 PURPOSE

This standard establishes uniform reliability program requirements and tasks for use during design, development, fabrication, test, and operation of space and launch vehicles.

## 1.2 APPLICABILITY

1.2.1 Application of the Standard. This standard, when appropriately tailored, is applicable to all prime, associate, and subtier contractors involved in the design, development, fabrication, test, and initial operation of space and launch vehicles.

1.2.2 Application Guidance. Application guidance for tailoring requirements to a particular procurement is contained in Appendix A. Appendix A and the "DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY" paragraph at the end of each task contain no contractor tasking, either directly or implied.

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# SECTION 2

# REFERENCED DOCUMENTS

## 2.1 GOVERNMENT DOCUMENTS

Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this standard to the extent specified herein.

Military Standards

| | |
|---|---|
| MIL-STD-721 | Definitions of Terms for Reliability and Maintainability. |
| MIL-STD-756 | Reliability Modeling and Prediction |
| MIL-STD-882 | System Safety Program Requirements |
| MIL-STD-1521 | Technical Reviews and Audits for Systems, Equipment and Computer Programs |
| MIL-STD-1540 | Test Requirements for Space Vehicles |
| MIL-STD-1546 | Parts, Materials, and Processes Standardization, Control, and Management Program for Spacecraft and Launch Vehicles |
| MIL-STD-1547 | Technical Requirements for Parts, Materials, and Processes for Space and Launch Vehicles |
| MIL-STD-1556 | Government Industry Data Exchange Program |
| MIL-STD-1629 | Procedures for Performing a Failure Mode, Effects and Criticality Analysis |
| MIL-STD-1635 | Reliability Growth Testing |

Military Handbooks

| | |
|---|---|
| MIL-HDBK-189 | Reliability Growth Management |
| MIL-HDBK-217 | Reliability Prediction of Electronic Equipment |

Other Documents

NPRD-3 Nonelectronic Parts Reliability Data, Reliability Analysis Center RADC

(Copies of this document may be obtained from Rome Air Development Center, Reliability Analysis Center, RADC/RAC, Griffiss Air Force Base, NY, 13441-5200)

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

2.2 ORDER OF PRECEDENCE

In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence. However, nothing in this standard shall supersede applicable laws and regulations unless a specific exemption has been obtained.

# SECTION 3

# DEFINITIONS AND ACRONYMS

## 3.1 DEFINITIONS

Terms are in accordance with the definitions of MIL-STD-721, MIL-STD-1521, MIL-STD-1556, MIL-STD-1629, and the following definitions:

3.1.1 Acquisition Activity. The acquisition activity is the Government office or agency acquiring the equipment, system, or subsystem to which this standard is being contractually applied.

3.1.2 Acquisition Phases

3.1.2.1 Conceptual (CONCEPT) Phase. The conceptual phase is the initial program acquisition phase that involves the identification and exploration of alternate solutions or solution concepts to satisfy a validated operational need.

3.1.2.2 Demonstration and Validation (VALID) Phase. The demonstration and validation phase is the program acquisition phase when selected candidate solutions are refined through extensive study and analyses; hardware development, if appropriate; test; and evaluations. Feasibility of one or more candidate solutions to satisfy the operational need is demonstrated.

3.1.2.3 Full-scale Engineering Development (FSED) Phase. The full-scale engineering development phase is the program acquisition phase when the system and the principal items necessary for its support are designed, fabricated, tested, and evaluated.

3.1.2.4 Production (PROD) Phase. The production phase is the program acquisition phase that starts with production approval and extends until the last system is delivered and accepted.

3.1.3 Circuit and Item Stress Analysis. Circuit and item stress analysis relates parts stress to circuit, module, component (unit), subsystem, and system performance and reliability, including influence by worst case parameter variations resulting from environmental effects, radiation effects, aging, input and output limits, initial operating points, and initial tolerances.

3.1.4 Compensating Features. Compensating features are special inspections, tests, controls, instructions, drawing notes or other provisions applied to a single point failure mode item to improve reliability and lessen chances of failure.

3.1.5 Component. A component is a functional unit that is viewed as an entity for purposes of analysis, manufacturing, maintenance, or record keeping. Examples are hydraulic actuators, valves, batteries, electrical harnesses, and individual electronic boxes such as transmitters, receivers, or multiplexers. Care should be exercised when the term component is encountered in other documents since, in some segments of industry, a piece part is referred to as a component and the term "unit" is interchanged with the term component.

3.1.6 Contracting Officer. A contracting officer is a person with the authority to enter into, administer, or terminate contracts and make related determinations and findings. The term includes authorized representatives of the contracting officer acting within the limits of their authority as delegated by the contracting officer.

3.1.7 Correlated or Sympathetic Failure. A correlated or sympathetic failure is the inability of two (or more) items to perform their function as the result of some single event, thus possibly negating redundancy and acting as a single point failure mode (SPFM) (e.g., loss of a raceway containing redundant power leads or a pyrotechnic shock causing parallel relays to chatter).

3.1.8 Critical Items. Critical items are those items which require special attention because of complexity, application of state-of-the-art techniques, the impact of potential failure, or anticipated reliability problems. The following are typical circumstances which would cause an item to be included on a critical items list.

a. Failure of the item would lead directly to severe injury or loss of human life.

b. A failure of the item would seriously affect system operation or cause the system to not achieve mission objectives. (See single point failure.)

c. A failure of the item would prevent obtaining data necessary to evaluate accomplishment of mission objectives.

d. The item has exhibited an unsatisfactory operating history relative to required performance or reliability.

e. The item has stringent performance requirements in its intended application relative to state-of-the-art.

f. The item does not have sufficient history or similarity to other items having demonstrated high reliability to provide confidence in its reliability.

g. State-of-the-art techniques are required to manufacture the item.

h. The items are stressed in excess of derating criteria.

i. The item has an operating, shelf-life, or environmental exposure limitation which warrants controlled storage or use.

j. The item is known to require special processing, handling, transportation, storage or test precautions.

k. The item's past history, nature, function, or processing warrants total traceability.

3.1.9 Failure Effect. The failure effect is the consequence of the failure mode including primary and secondary effects. Consideration should be given to long term as well as initial effects and should consider all modes of operation.

3.1.9.1 Local Effect. The local effect is the consequence(s) of a failure mode on the operation, function, or status of the specific item being analyzed.

3.1.9.2 Next Higher Level Effect. The next higher level effect is the consequence(s) of a failure mode on the operation, functions, or status of the items in the next indenture level above the indenture level under consideration.

3.1.9.3 End Effect. The end effect is the consequence(s) a failure mode has on the operation, function, or status of the highest indenture level.

3.1.10 Failure Mode. A failure mode is the way or manner in which an item fails.

3.1.11 Government Industry Data Exchange Program (GIDEP). The GIDEP is a program for the collection and exchange of reliability and other technical information between government agencies and industry. (See MIL-STD-1556.)

3.1.12 GIDEP Alert. A GIDEP Alert is a means of dissemination of information relating to an item deficiency which has been encountered, usually concerning parts, materials, or processes and their application.

3.1.13 Level of Indenture. The level of indenture of an item is a designation which identifies its relative complexity as an assembly or function. In a system the first indenture level is the system. Examples of lower indenture levels could be system segments (level 2), prime items (level 3), subsystems (level 4), components (level 5), subassemblies or circuit boards (level 6), and parts (level 7).

3.1.14 Mean Mission Duration. The mean mission duration is the average time an on-orbit space system is operational before a mission critical failure occurs. The mean mission duration is equivalent to mean time to failure for nonrepairable ground systems. The mean mission duration can be determined using the following formula, which may be calculated truncated at the end of some specified value or truncated at the time the contractor estimates wear out or depletion of expendables will occur.

$$\text{Mean Mission Duration} = \int_{t=0}^{T} R(t)\,dt$$

where $R(t)$ = Mission reliability model function
$T$ = Time at truncation

3.1.15 Pin-fault Analysis. A pin-fault analysis is a systematic design evaluation that examines, analyzes, and documents all potential inadvertent or spurious openings or closures of current-carrying paths, and determines the effect of each failure (e.g., analysis of connector pin-to-pin shorts, pin-to-ground shorts, inductive or capacitive coupling, printed wiring board traces open or short, and harness wiring opens or shorts).

3.1.16 Single Point Failure (SPF). A single point failure is any single hardware failure or software error which results in irreversible degradation of item mission performance below contractually specified levels. (The way or manner in which a single point failure of an item occurs is the single point failure mode (SPFM) of the item).

3.1.17 Sneak Condition. A sneak condition is a condition which causes the occurrence of an unwanted function or inhibits a desired function even though all components function properly whether electrical, mechanical, chemical, or software. Sneak conditions include:

a. Sneak paths, which are current paths that cause an undesirable function to occur or inhibit a desired function even though no component failure has occurred.

b. Sneak timing, which is incompatible hardware or logic operational sequences which can cause an undesirable function to occur or inhibit a desired function.

c. Sneak indicators, which are circuits which allow improper operation or control of sensors or their display devices that can indicate false or ambiguous system status.

d. Sneak labels, which are imprecise instructions or nomenclature on controls and operating consoles that lead to operator errors.

3.1.18 System. A system is a composite of equipment, skills, and techniques capable of performing or supporting an operational role, or both. A complete system includes all equipment, related facilities, material, software, services, and personnel required for its operation and support to the degree that it can be considered a self-sufficient item in its intended operational environment. The term system is also used in this standard to refer to the highest level of requirements and resource grouping applicable to the particular contract and analysis.

3.1.19 Tailoring. Tailoring is the process by which the individual requirements (tasks, sections, paragraphs, words or phrases, or sentences) of the specifications and standards are evaluated to determine the extent to which each requirement is most suited for a specific material acquisition and the modification of these requirements, where necessary, to ensure that each tailored document invokes only the minimum needs of the government.

3.1.20 Timely. As used in this standard, timely performance of a task, subtask, or effort is performance at a time when the results will be available to allow management actions to be taken to preserve system reliability, and to avoid or minimize schedule delays and cost impacts.

3.2 ACRONYMS

| | |
|---|---|
| CDR | Critical Design Review |
| CONCEPT | Conceptual phase of program acquisition |
| DCA | Design Concern Analysis |
| ESS | Environmental Stress Screening |
| FMECA | Failure Mode Effects and Criticality Analysis |
| FRACAS | Failure Reporting and Corrective Action System |
| FRB | Failure Review Board |
| FSED | Full-scale engineering development phase of program acquisition |
| GIDEP | Government Industry Data Exchange Program |
| PDR | Preliminary Design Review |
| PMP | Parts, Materials, and Processes |
| PROD | Production phase of program acquisition |
| RDGT | Reliability Development Growth Test |
| SOW | Statement of Work |
| SPF | Single Point Failure |
| SPFM | Single Point Failure Mode |
| VALID | Demonstration and validation phase of program acquisition |

# SECTION 4

# GENERAL REQUIREMENTS

## 4.1 RELIABILITY PROGRAM

The prime, associate, and subtier contractors shall implement and maintain a reliability program that is planned, scheduled, integrated, and developed in conjunction with other design, development, and production functions in accordance with the contractual statement of work, the requirements of this standard, and the program plan approved by the acquisition activity. The contractor shall establish and maintain an internal system of directives, procedures, instructions, specifications, and manuals to implement the contractually required reliability program. The program level of effort shall be adequate to fulfill the contractual quantitative and qualitative reliability requirements, and to support economical achievement of overall program objectives.

## 4.2 QUANTITATIVE REQUIREMENTS

The minimum acceptable item reliability shall be as stated in the configuration item specification. Quantitative reliability requirements for all major items shall be stated in the appropriate section of each item specification. The quantitative values not defined by the contracting officer, and those to be allocated from the system requirements, shall be established by the contractor though trade-off analyses prior to the Preliminary Design Review (PDR), and shall be updated for the Critical Design Review (CDR) and subsequent formal reviews.

## 4.3 INTEGRATION WITH OTHER REQUIREMENTS

The reliability program effort shall be closely coordinated with the design engineering and test programs as well as configuration management and integrated logistic support. The reliability program shall also be closely integrated with the related disciplines of quality assurance; maintainability; human engineering; system safety; software development; and parts, materials, and processes control to preclude duplication of effort and produce integrated cost-effective results.

## 4.4 INTEGRATED EQUIPMENT

Where items such as government furnished equipment or directed source hardware are to be integrated into the end item, known or estimated reliability predictions and analyses for these items shall be used in the contractor's reliability predictions and other analyses. Reliability related problems introduced by inclusion of such items shall be identified to the contracting officer.

# SECTION 5

## DETAILED REQUIREMENTS

The detailed requirements are contained in the following task descriptions.

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# SECTION 100

# PROGRAM SURVEILLANCE AND CONTROL TASKS

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# TASK 101

# RELIABILITY PROGRAM PLAN

## 101.1 PURPOSE

The purpose of Task 101 is to require the contractor to develop a reliability program plan which identifies and integrates all program tasks required to accomplish contractual reliability requirements.

## 101.2 TASK DESCRIPTION

101.2.1 A reliability program plan shall be prepared and shall include the following:

a. A description of how the reliability program will be conducted to meet the tailored requirements of this standard as specified in the contract, and to ensure that quantitative reliability requirements are met.

b. A detailed description of how each reliability task, including contractor added or modified tasks, is to be performed or complied with, including estimated time phasing. The purpose and expected results of each task and the planned methods for monitoring, assessing, reporting, and taking appropriate action regarding the status, accomplishments, and problems shall be described.

c. A description of the contractor's organizational element assigned responsibility and authority for implementing the reliability program tasks. Key personnel managing the reliability program shall be identified by name and title.

d. The identification of analyses or data bases required by the reliability program which may satisfy or be satisfied by an analysis or data base from a related design or specialty engineering function. The plan shall identify common users, earliest requirement, and variations in content and format for each user. Common requirements of the functional areas listed in paragraph 101.2.1.e as a minimum shall be considered. As an example, a computer-aided engineering data base would be used to obtain application data for use in performing a reliability prediction.

e. Interfaces between the reliability program and related programs or functions, including as a minimum:

    (1) Quality assurance
    (2) Human engineering
    (3) System safety
    (4) Part, material, and process controls
    (5) Maintainability
    (6) Logistic support analysis
    (7) Design engineering
    (8) System engineering
    (9) Software development
    (10) Test engineering
    (11) Manufacturing

f. A procedure for maintaining a list of items having the greatest impact on reliability, including known reliability problems. For each item on the list, the contractor shall also list an assessment of their impact on meeting contractual reliability requirements and any actions being taken to ensure that the items do not preclude meeting contract requirements.

g. Description of design guidelines and parts derating criteria, and the method for their dissemination to design personnel.

h. The reliability program plan shall describe the contractor's methods of controlling subtier contractor reliability. The reliability program plan shall include a list of subcontracts which contain quantitative reliability requirements or require a formal reliability program.

101.3 <u>DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY</u> (Reference paragraph 1.2.2)

101.3.1 Tailoring of the required reliability tasks.

101.3.2 If the reliability program plan is to become part of a Product Assurance or System Effectiveness Plan.

101.3.3 Any data item to be delivered as a result of this task should be specified on a DD Form 1423. Applicable data items for this task are listed in Appendix E. Normally the reliability program plan and initial list of reliability impact items (paragraph 101.2.1.f) are required with the contractor's proposal.

# TASK 102

## MONITORING AND CONTROL OF SUBCONTRACTORS AND SUPPLIERS

### 102.1 PURPOSE

The purpose of Task 102 is to require the prime contractor to perform appropriate surveillance and management control of subcontractor and suppliers reliability programs so that program progress can be monitored and timely management action taken when warranted.

### 102.2 TASK DESCRIPTION

102.2.1 The contractor shall ensure that subcontracted items obtained from first and all lower tier suppliers meet reliability requirements compatible with required system reliability. Intra-company work orders shall be considered subcontracts. Compliance with this task does not relieve the prime contractor of responsibility for the quality and reliability of all material delivered as a result of this contract.

102.2.2 The contractor's and subtier contractor's requirements documentation shall reflect the applicable requirements of this standard. The contractor's documentation shall be subject to review and disapproval by the contracting officer. All subcontracts requiring elements of this document to control the subcontracted item's reliability shall include provisions for on site review and evaluation of the suppliers reliability efforts by the prime contractor and by the acquisition activity.

102.2.3 The reliability program plan shall describe the contractor's methods of controlling subtier contractor reliability. The program plan shall include a list of all subcontracts which contain quantitative reliability requirements or require a formal reliability program. This list shall be maintained current and available for review at the contractor's facility.

102.2.4 The contractor shall:

a. Ensure that subcontracted items are defined by specifications, drawing, and technical documentation including numerical reliability requirements consistent with system reliability.

b. Verify the reliability of subcontracted hardware/software designs during subcontractor design reviews.

c. Require and ensure that subcontractor reliability tasks are performed in a timely manner.

d. Review subcontractor's reliability prediction and analysis for accuracy, proper approach, and ability to meet required reliability requirements.

e. Ensure that subcontractor's have a vigorous closed loop failure reporting and corrective action system (FRACAS) to eliminate causes of unreliability.

f. Integrate the subcontractors FRACAS data with the prime contractor's FRACAS.

g. Ensure that sufficient testing is performed on subcontracted items to support the system reliability demonstration.

102.2.5 The contractor shall have a system for identifying problems which may prevent subcontractors from meeting reliability requirements. The contractor shall notify the contracting officer when such problems exist and indicate actions being taken to resolve the problems.

102.3 <u>DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY</u>:

102.3.1 Note that Task 104 is a prerequisite for specifying tasks 102.2.4.e and 102.2.4.f.

# TASK 103

## PROGRAM REVIEWS

### 103.1 PURPOSE

The purpose of Task 103 is to establish a requirement for the contractor to conduct reliability program reviews at specified points in time to ensure that the reliability program is proceeding in accordance with contractual milestones and that the system, subsystem, equipment, and component quantitative reliability requirements will be achieved in delivered equipment.

### 103.2 TASK DESCRIPTION

103.2.1 The reliability program shall be planned and scheduled to permit the contractor and acquisition activity to periodically review program status. Formal review and assessment of progress in meeting contract reliability requirements shall be conducted at major program reviews specified by contract.

103.2.2 The contractor's reliability personnel shall participate in contractor and subcontractor design reviews, PDRs, CDRs, and in internal design reviews, such as pre-PDRs, post-PDRs, and pre-CDRs of an item. Results of these design reviews shall be recorded, and shall be available to the acquisition activity for detailed examination at the contractor's or subcontractor's facilities during the term of the contract. Contractor and subcontractor PDRs, CDRs, internal design reviews, and design audits should include:

a. Status of all applicable reliability tasks at the time of the review, including progress on the task and results to date.

b. A review of current and potential reliability problems, potential impact on the program, and plans for their resolution.

c. The reliability content of specifications, and the ability of the current design to comply with reliability requirements.

103.2.3 The contractor shall develop and apply a procedure to document and follow-up on design review decisions, action items, and agreements to ensure that the design reflects the results of design reviews.

103.2.4 The contractor shall notify the contracting officer of design reviews at least ten working days prior to the review. The acquisition activity reserves the right to have representatives attend program reviews as an active participant and to attend internal and subcontractor reviews as an observer.

103.3 DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY (Reference paragraph 1.2.2)

(R) 103.3.1 The contract should specify major program reviews indicated in paragraph 103.2.1. This is usually done through the use of MIL-STD-1521 as a compliance document in the SOW. When MIL-STD-1521 is contractually specified, the requirements of this task may be fulfilled by appropriate tailoring of MIL-STD-1521.

103.3.2 Any data item to be delivered as a result of the task should be specified on a DD Form 1423. Applicable data items for this task are listed in Appendix E.

# 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. This failure reporting system shall include procedures for recording and analysis of each failure to determine its cause, determination of actions necessary to correct deficiencies in the failed hardware, determination of actions necessary to eliminate the cause of the failure, verification that the corrective action, as implemented, is adequate to correct the problem, and to ensure that all actions are properly documented.

### 104.2 TASK DESCRIPTION

104.2.1 The contractor shall maintain and shall require subcontractors to maintain a closed loop FRACAS as required in this task description. Data from the subcontractor's FRACAS shall be integrated into the contractor's FRACAS. Procedures developed to implement this task shall be integrated and coordinated with procedures developed for handling nonconforming items and corrective action under the quality assurance program requirements of the contract.

104.2.2 On qualification and production hardware and software, failures and anomalies shall be reported at all levels of test and inspection after first application of power at lowest level of assembly. Each failure shall require investigation for cause (failure analysis) and corrective action. An unscheduled adjustment, other than a calibration made during maintenance actions, shall be considered a failure for the purposes of the FRACAS. Piece part failure analyses shall be incorporated into the FRACAS. Failures of equipment undergoing reliability development growth testing (RDGT) shall be included in the FRACAS. Functional failures caused by software or hardware to software interfaces shall be included in the FRACAS and be subject to the same failure analysis and corrective action processes.

104.2.3. Failure analysis shall be conducted to the lowest level of indenture necessary to identify the failure cause and mechanism. The analysis shall begin with an on-the-spot review by reliability or quality engineering supervision and the responsible test engineer this review shall be conducted prior to removal of the failed hardware from the test setup, unless removal of the hardware is required for safety. The failure analysis shall include evaluation of potential overstress of other parts or components due to the failure. Failure analysis shall be planned to minimize the probability of improperly sequenced actions that could obscure the basic failure cause.

104.2.4 In order to allow acquisition activity participation in the failure analysis, the contractor shall notify the contracting officer within one working day of system level, mission or schedule critical failures.

104.2.5 When the cause of the failure has been determined, corrective actions shall be developed which correct the suspect item, eliminate the underlying failure cause, and prevent its recurrence. Corrective actions shall be coordinated with design engineering, quality assurance, manufacturing and with other activities, as appropriate. Corrective actions shall be implemented in a timely manner. Adequacy of corrective actions performed shall be verified through appropriate testing including as a minimum, rerunning the test in which the failure originally occurred. The failure report shall not be closed until corrective actions are implemented, their adequacy verified, and approval of the acquisition activity is obtained. All failures shall be resolved prior to flight.

104.2.6. All hardware with the same configuration as the failed item shall be considered suspect and suitably controlled. Serialized suspect flight hardware shall be addressed by serial number in corrective action statements.

104.2.7 The contractor's FRACAS shall contain a suspense audit system including assignment of suspense dates for failure analysis, corrective actions and follow-up when suspense dates are not met. Delinquencies shall be reported to the program management level, and addressed at program management reviews.

104.2.8 The contractor's FRACAS shall have provisions for a periodic analysis and summarization of FRACAS data to identify trends, recurring failures and open and closed failure reports that could significantly affect reliability performance, schedule or cost for presentation to program management. The contractor shall use appropriate statistical techniques for summarizing, analyzing, and presenting the data. The analysis shall detect trends in failure causes as well as hardware and software configurations in all levels of assembly, test, and use.

104.2.9 The contractor's FRACAS records shall include the following information as a minimum:

a. Date of the failure.

b. Identification of the failed item including part number, nomenclature, and serial number.

c. Description of the test conditions at the time of failure including identification of test procedure and revision, test paragraph, environmental conditions, and previous environments the item was subjected to, if pertinent.

d. Symptoms of the item under test at the time of failure.

e. Results of attempts to repeat failure, when applicable.

f. Signature of the person initiating the failure report.

g. Signature of the person verifying the failure.

h. Steps taken to determine the cause of the failure and their results.

i. Identification of the part or parts that failed.

j. Inherent cause of the failure.

k. A statement regarding the effects of the failure and failure analysis on the failed item under test.

l. If redundant, an assessment of the impact of the failure on the operation of the system using the redundant path.

m. Identification and location of flight hardware with the same configuration as the failed item under test. This hardware is considered suspect.

n. A description of corrective actions taken with the failed item under test and other suspect hardware, scheduled accomplishment and appropriate concurrences.

o. A description of corrective actions taken to eliminate the failure cause and prevent its recurrence, scheduled accomplishment, and appropriate concurrences.

p. Actions taken to verify corrective actions including the extent of retest, the results, and the signature of the individual verifying the corrective action.

104.2.10 The contractor shall participate in the Government Industry Data Exchange Program (GIDEP) to the extent necessary to generate ALERTs and receive ALERTs from the GIDEP Operations Center. The contractor shall screen ALERTed parts against his parts list. The contractor shall notify the contracting officer of the usage of any suspect part, describe its location and usage in the system, the effects of its failure on the system, and actions taken to mitigate these effects or reduce the probability of failure. The contractor shall be able to identify and locate suspect parts incorporated into hardware. Investigations of ALERTs shall be addressed at parts, materials, and processes control board (PMPCB) meetings.

104.2.11 To implement the FRACAS during testing of research and advanced development nonflight and prequalification hardware, logs shall be maintained of significant events, discrepancies and failures. These logs shall represent a complete failure and discrepancy history of each item. These logs shall be periodically reviewed and hardware and design corrective actions taken to eliminate failure causes.

104.3 DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY (Reference paragraph 1.2.2)

104.3.1 The requirement for the proposal to include an estimate of the number of failures expected by program phase and the basis for the estimate for use during negotiations should be included in the request for proposal.

104.3.2 Any data item to be delivered as a result of this task should be specified on a DD Form 1423. Applicable data items for this task are listed in Appendix E.

# TASK 105

## FAILURE REVIEW BOARD (FRB)

### 105.1 PURPOSE

The purpose of Task 105 is to establish a failure review board to review failure trends, significant failures, corrective action status, and to ensure that adequate follow-up and corrective actions are taken in a timely manner and are properly recorded.

### 105.2 TASK DESCRIPTION

105.2.1 An FRB shall be established and maintained to review failure trends, significant failures, delinquent corrective actions, and ensure adequate and timely corrective actions. The FRB shall meet regularly, normally weekly, after occurrence of the first reportable failure. All failure occurrence information shall be available to the FRB. All failures shall require closeout approval by the FRB. The FRB shall monitor the status of corrective action implementation. Minutes of FRB activity shall be recorded and kept on file for detailed examination by the acquisition activity during the term of the contract.

105.2.2 Contractor FRB members shall include representatives from system engineering, design engineering, reliability, parts engineering, materials and processes engineering, system safety, manufacturing, and quality assurance as a minimum. The acquisition activity reserves the right to appoint a representative to the FRB with right of disapproval of FRB decisions. The chairman of the FRB shall have sufficient authority to resolve conflicts between members and to ensure prompt and effective implementation of corrective action.

105.2.3 This task shall be coordinated with procedures for handling of nonconforming material and corrective action required by the quality assurance provisions of the contract to ensure there is no duplication of effort.

### 105.3 DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY

(Reference paragraph 1.2.2):

105.3.1 Task 104 is a prerequisite for specifying this task.

105.3.2 Specify the organizational level of the FRB chairman, when appropriate.

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# SECTION 200

# DESIGN AND EVALUATION TASKS

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# TASK 201

# RELIABILITY MODELING

## 201.1 PURPOSE

The purpose of Task 201 is to require development of a reliability model to be used for making numerical apportionments and reliability predictions from the system through component levels.

## 201.2 TASK DESCRIPTION

201.2.1 The contractor shall develop and maintain a reliability mathematical model based on system, subsystem, and equipment functions, for the system and for each configured item required to perform the mission functions. Models shall be developed using the methods defined in MIL-STD-756 or unique methods appropriate for contractor equipment. A reliability block diagram shall be developed and maintained for the system. The model shall be made to the component level, as a minimum, and shall include probability of success with associated failure rates. The reliability block diagram shall be traceable to and cross-referenced to the functional block diagram, schematics and drawings. The physical location of redundancy switching circuits shall be clearly identified in the model. Nomenclature of items used in reliability block diagram shall be consistent with that used in functional block diagrams, drawings, schematics, weight statements, power budgets, and specifications. The reliability mathematical model shall be updated with information resulting from FMECAs, reliability tests, other relevant tests, 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, subsystem, and component level analysis models. The model shall include software, and software to hardware interfaces, as necessary to define mission reliability.

201.2.2 The model outputs shall be expressed in terms compatible with contractual reliability requirements and other reliability terms as specified.

201.2.3 When specified in the SOW, models shall be developed for alternate and degraded operational modes and to support logistic support analysis.

## 201.3 DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY

(Reference paragraph 1.2.2).

201.3.1 Tasks 202 and 203 are normally specified in conjunction with this task.

201.3.2 Identification of numerical reliability requirements, mission parameters, and operational constraints.

201.3.3 Level of indenture to which model should be developed if other than component level.

201.3.4 Identification of alternate model requirements (reference paragraph 201.2).

201.3.5 Any data item to be delivered as a result of this task should be specified on a DD Form 1423. Applicable data items for this task are listed in Appendix E.

# TASK 202

## RELIABILITY ALLOCATIONS

### 202.1 PURPOSE

The purpose of Task 202 is to ensure that quantitative system reliability requirements are allocated or apportioned to lower levels of indenture.

### 202.2 TASK DESCRIPTION

202.2.1 Quantitative contractual reliability requirements shall be allocated to the component level or lower if necessary to determine a reliability requirement for a configured item specification and shall be used to establish baseline requirements for designers and subcontractors. Requirements consistent with allocations shall be imposed on the subcontractors and suppliers by inclusion in item procurement specifications.

202.2.2 All allocated reliability values established by the contractor and included in contract item specifications shall be consistent with the reliability model and any changes thereto are subject to acquisition activity review.

202.2.3 The reliability allocations shall include all software and firmware.

### 202.3 DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY
(Reference paragraph 1.2.2)

202.3.1 Task 201 is a prerequisite for specifying this task.

202.3.2 Any data item to be delivered as a result of this task should be specified on a DD Form 1423. Applicable data items for this task are listed in Appendix E.

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# TASK 203

# RELIABILITY PREDICTIONS

## 203.1 PURPOSE

The purpose of Task 203 is to estimate the reliability of the system and to determine if contractual reliability requirements can be achieved with the proposed design.

## 203.2 TASK DESCRIPTION

203.2.1 The contractor shall perform reliability predictions for all items using methods approved by the contracting officer. Predictions shall account for and differentiate between each mode of item operation as defined in the item specification and the reliability program plan. The probability that the system can perform the required mission shall be determined as a function of time for the period from initial use through design life or wearout. This prediction shall include alternate missions and modes of operation. The resulting data shall be presented in tabular and graphical formats. The contractor shall perform these predictions using the associated reliability mathematical model and reliability block diagram. The contractor is encouraged to use models and failure rates unique to the equipment, subject to approval of the contracting officer.

203.2.2 The reliability prediction shall include predictions for software and firmware reliability as related to system reliability.

203.2.3 When a Failure Mode, Effects, and Criticality Analysis (FMECA) is required, results of the FMECA shall be reflected in the predictions. Items excluded from the prediction as mission nonessential shall have substantiating FMECAs which verify that the item failure cannot cause mission failure. Prior to such exclusions from the predictions, an assessment shall be made relating functioning of the item to system performance and approval shall be obtained from the contracting officer. Exclusions shall be clearly identified in all analyses and predictions. Usage of operational duty cycles of less than 100 percent shall require approval of the contracting officer and be clearly identified in all analyses and prediction.

203.2.4 Predictions for electronic equipment shall be made using the methods and failure rates contained in MIL-HDBK-217, or alternatives approved by the contracting officer. Predictions for mechanical, electrical, and electromechanical equipment shall be made using NPRD-3, contractor data, or other alternative data, subject to approval of the contracting officer. A probabilistic approach to design and reliability prediction shall be considered for mechanical items for which stress and strength relationships can be estimated. The failure rate adjustment factor for standby operation and storage shall be submitted with substantiation to the contracting officer for approval. A standby failure rate adjustment factor of not less than 0.5 shall be used for failure rates of one or less failures per $10^8$ hours.

203.2.5 The Mean Mission Duration for the system shall be predicted truncated at the end of the expected mission life and truncated at the end of useful life (e.g., at the point in time that the contractor estimates wearout or depletion of expendables will occur).

203.2.6 For spacecraft, as part of the reliability prediction, an end-of-life prediction shall be made. The end of life prediction shall be made in a probabilistic sense considering such items as depletion of expendables, solar cell, thermal protection, and storage battery degradation.

203.3 DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY (reference paragraph 1.2.2)

203.3.1 Task 201 is a prerequisite for specifying this task.

203.3.2 Any data item to be delivered as a result of this task should be specified on a DD Form 1423. Applicable data items for this task are listed in Appendix E.

203.3.3 Any items, other than the system, for which the mean mission duration should be calculated.

203.3.4 The failure rate adjustment factor for standby operation.

203.3.5 Failure rates or predictions for government furnished equipment.

203.3.6 Identification of item life profile and mission profile.

# TASK 204

# FAILURE MODES, EFFECTS, AND CRITICALITY ANALYSIS (FMECA)

## 204.1 PURPOSE

204.1.1 The purpose of Task 204 is to determine and document all possible failure modes and their effects on mission success through a systematic analysis of the design. The analysis is intended to identify needed reliability improvements in a timely manner and to foster interchange of design information with other program activities such as system safety, instrumentation, test, and other reliability analyses.

204.1.2 In addition to the above, the FMECA shall be used for the following specific purposes:

a. To ensure that an organized and exhaustive effort has been made to identify all failure modes, that their mission effects have been determined, and that either corrective or compensating action has been taken or that the risk to program success associated with no further action is acceptable and approved by the contracting officer.

b. To identify single point failure modes (SPFM) and define their effects.

c. To identify those areas of the design where redundancy for critical functions should be implemented.

d. To identify compensating features for those single point failure modes whose elimination is impractical.

e. As an aid in identifying functions, including redundancy, which are not or cannot be tested.

f. As a ranking technique for concentrating program attention on the most serious failure modes.

g. As a basis for establishing and updating a critical items list and critical item control plans.

h. As an input to reliability modeling, predictions, and assessments.

i. As an iterative design tool to achieve the most reliable design consistent with program objectives.

j. As a design evaluation tool for use in selecting the optimum design from competing design candidates and as inputs to design trade-offs.

k. As a diagnostic tool during mission planning, testing, and operations.

l. To assure that the effects of failures and their criticality on personnel, equipment, and facilities are analyzed and documented in accordance with the definitions and criteria for the system safety hazard analyses of MIL-STD-882.

m. As a criterion for test planning, manufacturing and quality control, instrumentation points, preflight checkout, and related program activities.

n. As an aid in determining flight and ground operational constraints and in defining failure indications and recovery actions for orbital operation and contingency plan documents.

o. As an input to logistics support and maintainability. Maintainability, human engineering design, and operational criteria shall be developed and implemented as a result of the FMECA.

p. To identify problem areas to be avoided in manufacturing work instructions; in selecting materials, processes, and equipment; and in inspection, test, and quality control planning for manufacturing.

## 204.2 TASK DESCRIPTION

204.2.1 The FMECA shall be conducted in accordance with this task and MIL-STD-1629. Tasks 101, 102, and 105 of MIL-STD-1629 shall be performed. The major thrust of these analyses shall be identification and elimination of, or compensation for, failure modes to improve reliability. Emphasis shall be placed on eliminating SPFM by design, or where elimination is not feasible, on reducing SPFM likelihood or impact by incorporating compensating features. All corrective actions, procedural changes, tests, quality control measures, or other compensating features described in the FMECA shall be incorporated into the methods which the contractor establishes for critical item control as required by this standard.

204.2.2 The system under analysis shall include all contractual items, equipment supplied by subcontractor and associate contractors, and integration activities required by the contract such as those related to Government furnished equipment. The FMECA shall include electrical, electronic, mechanical, thermal, electromechanical, hydraulic, pneumatic, optical, structural, propulsion, and ordnance mission hardware.

204.2.3 In addition to hardware failure modes analyses, the FMECA shall include consideration of potential system failure due to software, test equipment and procedures, human error, operational procedures, and loss or change in characteristics of inputs.

204.2.4 Mission Phases. The FMECA shall be conducted for all phases of a mission including prelaunch (launch preparation), launch, transfer orbit, orbit injection, acquisition, normal orbital operation, reacquisition, orbit changes, and reentry, as these phases are defined in the applicable system requirement document. Even though the contractor's hardware may function during only a limited portion of the mission, the effect upon interfacing hardware during these phases and the effect upon subsequent operation of the contractor's hardware shall be determined. Emphasis shall be placed on critical portions of the mission where reliability estimates provide little information, such as the launch portion of a satellite mission.

204.2.5 System Operating Modes. The FMECA shall be conducted for all modes of system operation including normal operating modes, contingency modes, dormant modes, back-up autonomous, nonautonomous modes, ground-controlled modes, and transition between modes as these are defined in applicable system requirements documents.

204.2.6 Failure Modes Analyzed. In addition to the failure conditions cited in Task 101 of MIL-STD-1629, failure modes identified in the following shall be incorporated in the FMECA.

204.2.6.1 Redundancy Effects. The effect upon the system resulting from redundancy management shall be included. Interfaces and isolation techniques for redundant elements shall be analyzed to ensure that the desired redundancy is not negated due to failure of any interfaces or isolation techniques (especially wiring and other circuit paths). Redundant elements which are not independently testable shall be regarded as potential single point failure modes. Typical factors include the following:

a. Malfunction signaling, sensing, logic, and switching

b. Effect of subsystem selections

c. Ability to check out redundant items

d. Failure detectability in operation

e. Effect of correlated or sympathetic failures

f. Effect of inadvertent switching

g. Effect of early or late time-out or time-in events.

204.2.6.2 Related Activities. The FMECA shall include failure modes detected by related analyses, investigations, tests, reviews, and other studies. Failure modes identified during the following activities shall be integrated with the FMECA as specified below:

a. The circuit and item stress analysis, Task 206, if applicable.

b. Dynamic analyses, analyses of structures, and mechanisms that are conducted in the performance of the contract.

c. Test failures, inspection discrepancies, GIDEP alerts, information on operation of similar equipment.

d. System safety analyses.

204.2.7 Failure Detection. Emphasis shall be placed on those conditions where timely action is required, in particular, those failures which, if left alone, would progress to an uncorrectable state and cause mission failure.

204.2.7.1 Flight Detection. The FMECA shall verify that instrumentation, including telemetry, is provided for purposes of in-flight failure detection. The FMECA shall verify that the instrumentation is adequate to support redundancy management, and provides for isolation of failure to significant functional elements. When the same telemetry indicator is used to represent more than one potential problem condition, the FMECA shall define the effect of misinterpreting the indicator and correcting for the wrong condition. For vehicles where command and control is possible, time limits from detection of a problem to implementation of corrective action shall be defined.

204.2.7.2 Ground Test and Checkout. The FMECA shall verify that system functions are testable to ensure satisfactory status prior to commitment to flight.

204.2.7.3 Safety Related Failures. The FMECA shall verify that telemetry and test instrumentation is adequate to detect safety related failure conditions.

204.2.8 Types of FMECAs. A number of different types of FMECAs are listed in the following subparagraphs. These FMECAs shall be developed in conjunction with each other, so that the output of one FMECA can be the input to another.

204.2.8.1 Functional FMECA. The contractor shall perform a functional FMECA, including both time-dependent and time-independent failure modes. The functional FMECA normally is used when hardware items cannot be uniquely identified, or when system complexity requires analysis from the initial indenture level downward through succeeding indenture levels. All system functions, including electrical, electronic, mechanical, structural, chemical, ordnance, command, telemetry, and software shall be identified in addition to the redundancy contained in each. The contractor shall develop a functional block diagram of the system or applicable portions, traceable to the corresponding equipment. The contractor shall, by search, analysis, or simulation, determine the effects on system functions of single failures in accordance with the requirements of this standard. The analysis shall include the response of the system to failures where the ability to restore full system function or preserve partial system function by the use of redundancy or by other action may depend upon the elapsed time since the failure. Examples of these kinds of failures include those which lead to control instability, cyclic thermal or mechanical stress, or leakage of propellants. The functional FMECA shall make provisions for different levels of analysis based on the mission phase and function criticality for which the function is being analyzed.

204.2.8.2 Hardware FMECA. As the design progresses, the contractor shall perform a more detailed FMECA, based on the physical designs of the system, subsystems, and components being analyzed. The analysis shall be performed down to the piece part level in the priority established by the criticality classification of the mission functions. Piece part failure modes shall be analyzed when necessary to identify a component failure mode, its cause, or its effect. A component FMECA shall be performed on each component regardless of whether or not the component or its function is redundant in the system. For redundant components, the FMECA shall be in sufficient depth to identify failure modes that can influence redundancy implementation.

204.2.8.3 Interface FMECA. The contractor shall identify and analyze all of the interfaces at all levels of hardware. The contractor shall develop a functional, hardware related, block diagram of the system, or applicable portions, traceable to the corresponding equipment. Failures in any one subsystem component or interconnecting circuit which cause thermal, electrical, or mechanical damage or degradation to any other subsystem or component, or within the component, shall be identified. Any interfaces between the space vehicle and payloads shall be included. The analysis shall include software interfaces that can have an impact on mission success. Pin-fault analysis shall be conducted as part of this FMECA.

204.2.8.4 Product Design-manufacturing FMECA. The contractor shall analyze the manufacturing documentation, such as circuit board layouts, wire routings, connector keying, and hardware implementation of the design to determine if new failure modes have been introduced as a result of production implementation of the design. The FMECA shall be performed initially from design drawings and shall be updated by reference to current manufacturing work instructions.

204.2.8.5 Large Scale Integration. For the purposes of this standard, Very Large Scale Integrated Circuits (VLSIC), Very High Speed Integrated Circuits (VHSIC), Custom Large Scale Integration (CLSI), and Hybrid Semiconductor Devices shall be considered to be components. Hardware FMECA (paragraph 204.2.8.2) and product design-manufacturing FMECA (paragraph 204.2.8.4) shall be performed on these devices. Early emphasis, at or prior to PDR, shall be placed on hybrids, on devices newly designed or modified for the system, and on devices with no history of successful use in similar applications.

204.2.8.6 Sneak Analysis. As part of the Functional FMECA (paragraph 204.2.8.1) and Interface FMECA (paragraph 204.2.8.3) the contractor shall apply the functional clue list (Appendix B.) to identify sneak conditions. The analysis shall employ a systematic approach to ensure that all system functions are performed when and only when required and that any sneak conditions are identified. As part of the hardware FMECA the contractor shall apply the design clue list (Appendix C) to identify design related sneak conditions.

204.2.9 Timeliness. The FMECA shall be performed in a timely manner, that is, at such time in the flow from concept to end system use that the FMECA may effectively fulfill the purposes stated in paragraph 204.1.2. The analysis shall be scheduled and completed concurrently with the design effort so that the design reflects the results of the analysis. The FMECA shall be maintained current with the design and other program activities.

204.2.10 FMECA Update and Review. Changes to the design, fabrication, packaging, procedural, or other activities shall require an update of the affected portion of the FMECA and Critical Items List. This update shall be accomplished within 30 days of the change. The FMECA shall be updated whenever testing reveals a failure mode that was not included in the FMECA analysis.

204.2.11 Mission Readiness Review. After CDR, the FMECA shall be reviewed for each space vehicle and launch vehicle. These FMECA reviews shall be conducted in conjunction with each applicable hardware technical audit and mission readiness review. As a result of each FMECA review, the FMECA shall be updated as necessary to include an analysis of all changes to the design, test results to date, and the as-built configuration of each spacecraft and launch vehicle. All new single point failures shall be listed and reviewed to ensure each is eliminated or the mission effects reduced in accordance with paragraphs 204.2.12.1 of this standard. The effectiveness of each single point failure correction shall also be reviewed and the residual risk reported.

204.2.12 FMECA Data

204.2.12.1 Single Point Failure Modes (SPFM). The contractor shall identify all SPFMs, classify each by severity of mission impact, and present the results at all design reviews, technical audits, and mission readiness reviews. Mission critical SPFMs shall be eliminated from the design or their mission effects reduced to the lowest practical level. The contractor shall develop and maintain a current listing of all SPFMs characterized by mission impact, probability of occurrence, and practicality of correction. The contractor shall recommend compensating features in the form of design, manufacturing, or other corrective actions to eliminate or reduce the mission effects or probability of occurrence of each SPFM. Justification shall be given for each single point failure that is not detectable during ground test and checkout. This record shall be available for inspection by the Government on request.

204.2.12.2 Configuration Identification. The contractor shall identify FMECA entries and items directly and unambiguously to the specific item configuration (such as specific drawing number revision or engineering change proposal) covered by the analysis. Traceability shall be maintained between all elements of the FMECA, e.g., from component to subsystem, to system level FMECAs.

204.2.12.3 Analysis Data. In addition to information required by Task 101 and 102 of MIL-STD-1629, the FMECA shall include the following data:

a. Redundancy management conditions as noted in paragraph 204.2.6.1.

b. Symptoms and warnings prior to failure occurrence shall be included.

c. Critical items shall be identified. The Critical Items List shall also be maintained as a separate document.

d. Identification of failure modes impacting safety.

e. An estimate of the probability of occurrence of each failure mode. For other than uncorrected SPFMs (paragraph 204.2.12.1) and critical items, probability estimates may be by range groupings indicating relative probabilities if the actual estimates are not available.

f. Identification of failure modes for which ground checkout, launch preparation checkout or flight instrumentation is inadequate for timely detection.

204.2.12.4 Supporting Data. In addition to the analysis results of paragraph 204.2.12.3, the FMECA shall include the following supporting information:

a. A system, system segments, subsystem, and component description including a functional block diagram. The functional block diagram should show all items comprising a system, system segment, subsystem or component, the series and redundant relationships among the items, the interconnections between the items, the interface circuitry, the monitoring points, the switching capability, each of the item's inputs and outputs, and inputs to the system as a whole. A separate functional block diagram may be required. The description shall include a comprehensive narrative description of the operation of each item for each system operating mode with any unusual functions fully described.

b. A cross-reference to data base information used in support of the FMECA, with significant data extracted as needed for completeness and clarity.

c. Any other required graphical data such as the following shall be included as required to support the FMECA:

1. Functional flow diagrams
2. Cross section drawings
3. Cutaway views
4. Worst case analysis data
5. Fault trees
6. Connector and wiring lists
7. Schematic diagrams
8. Design layouts
9. Printed circuit board layouts

204.2.13 Audit and Review. The contractor shall develop techniques for determining the adequacy of their FMECA, subject to the approval of the contracting officer. These techniques shall include a contractor audit and review jointly with the Government (or its designated representative). The review shall include an overall evaluation, a detailed review of selected critical design characteristics, associated critical manufacturing process, and a sampling review of other areas. If the review process discloses undetected SPFM, then the FMECA procedures and their implementation shall be evaluated and a corrective action plan submitted to the contracting officer. Corrective action may include use of modified methods or different analysts as required to ensure adequacy of the FMECA.

204.3 DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY (Reference paragraph 1.2.2)

204.3.1 Tasks 201, 203 and 208 are generally specified in conjunction with this task.

204.3.2 The approach to be used in performing the criticality analysis (Task 102, MIL-STD-1629) should be specified. Refer to para. 50.8.

204.3.3 Schedule of Delivery of Contract Data Requirements List (CDRL) Items. In order to facilitate timely and effective use of the FMECA and to foster early agreement on FMECA planned approach and content, it is recommended that the submittal of Contract Data Requirements List deliverables be required in accordance with the following typical schedule:

204.3.3.1 With proposal: FMECA Plan (Task 105, MIL-STD-1629), system function FMECA (paragraph 204.2.8.1). Preliminary single point failure mode list (paragraph 204.2.12.1).

204.3.3.2 Prior to System PDR: System functional FMECA update (paragraph 204.2.8.1) and Interface FMECA (paragraph 204.2.8.3).

204.3.3.3 Prior to component PDR, if a component PDR is conducted (otherwise at a comparable time in the component design schedule): Component FMECA (paragraph 204.2.8.2) and update of Interface FMECA (paragraph 204.2.8.3).

204.3.3.4 Prior to first release of product design drawings or equivalent information: Product design-manufacturing FMECA (paragraph 204.2.8.4).

204.3.3.5 Update. In addition to the initial submittals above, updates should be submitted prior to each subsequent major activity (e.g., Critical Design Review, Physical Configuration Audit). In some cases it may also be desirable to require addition submittals, either on a periodic basis, or in conjunction with other milestone.

204.3.4 Any data item to be delivered as a result of this task should be specified on a DD Form 1423. Applicable data items for this task are listed in Appendix E.

# TASK 205

## DESIGN CONCERN ANALYSIS (DCA)

### 205.1 PURPOSE

The purpose of Task 205 is to identify design weaknesses which can manifest themselves as failures or degraded performance during the useful life of the system.

### 205.2 TASK DESCRIPTION

205.2.1 The contractor shall perform an independent analysis of the design to identify design weaknesses such as inadequate redundancy provisions, timing inconsistencies, out-of-specification operating modes, improperly applied components, and unnecessary components. The contractor shall develop a design concern list appropriate to the equipment he is designing. Appendix D contains examples of potential design concerns. The contractor shall systematically apply the design concern list to identify design weaknesses. The DCA shall be scheduled and completed concurrently with the design effort so that the design reflects the analysis conclusions and recommendations. The results of the DCA shall be documented including equipment analyzed, design weaknesses identified, and their disposition. The results of the DCA shall be available for acquisition activity review and new failure modes shall be incorporated into the FMECA, if applicable.

205.2.2 The contractor's procedure for conducting DCA and a sample worksheet shall be submitted to the contracting officer prior to PDR for approval. The procedure shall identify who, by discipline, will perform the analysis and what parts and components are to be analyzed.

205.2.3 The ultimate intent is for DCA to be conducted as part of a reliability and maintainability computer aided design (RAMCAD) system. however, specification of this task shall not be construed as a requirement for the contractor to have a reliability and maintainability computer aided design (RAMCAD) system. When applicable the computerized DCA technique shall use the most current computer aided design data, be modular, provide computer compatible results in a project standard format, and be integrated with other computerized techniques in a manner that avoids duplication of effort.

### 205.3 DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY

(Reference paragraph 1.2.2)

205.3.1 Items or criteria for selection of items to be subjected to DCA.

205.3.2 Submittal of DCA procedure and DCA worksheet in accordance with paragraph 205.2.2.

205.3.3 Any data item to be delivered as a result of this task should be specified on a DD Form 1423. Applicable data items for this task are listed in Appendix E.

# TASK 206

# CIRCUIT AND ITEM STRESS ANALYSIS

## 206.1 PURPOSE

The purpose of Task 206 is to examine the effects of part and circuit parameter tolerances and parasitic parameters over the range of specified operating life and conditions and to ensure compliance to approved parts derating criteria.

## 206.2 TASK DESCRIPTION

206.2.1 During the design and development phase, the contractor shall perform sensitivity analyses which relate the parts operation and stress to circuits, modules, components, subsystems and system performance as they are influenced by:

a. Maximum input and output variation

b. Maximum line voltage variations and line transients.

c. Maximum part parameter variation.

d. Maximum performance demands and variations.

e. Maximum and minimum environmental conditions

f. Fail safe provisions.

g. Redundancy provisions.

h. Radiation effects, as applicable.

i. Parameter drift due to aging.

j. Transients due to turn-on, turn-off and state changes.

k. Fatigue due to cyclical loading.

206.2.2 A worst case analysis shall be performed to verify that, given reasonable combinations of parts tolerance buildup, the circuitry being analyzed will function within specification requirements.

206.2.3 A circuit stress analysis shall be performed to ensure that approved derating requirements have been complied with.

206.2.4 These analyses shall be scheduled and performed as an integral part of the design effort and analysis results shall be presented at design reviews. These analyses shall be performed in conjunction with the contractor's testing to verify design margins. The contractor shall correlate the results of these analyses with the FMECA, when Task 204 is contractually imposed. Results of these analyses shall be available for acquisition activity review prior to item CDR.

206.3 DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY (Reference paragraph 1.2.2)

206.3.1 Identification of the environmental envelope within which the equipment is to operate.

206.3.2 Specification of or criteria for selection of parts and circuits to be analyzed.

206.3.3 Any data item to be delivered as a result of this task should be specified on a DD Form 1423. Applicable data items for this task are listed in Appendix E.

# TASK 207

## PARTS, MATERIALS, AND PROCESSES (PMP) PROGRAM

### 207.1 PURPOSE

The PMP program for spacecraft and launch vehicles should be planned and accomplished in conjunction with the Reliability Program. It is usually specified as a separate item in the SOW using MIL-STD-1546, appropriately tailored. This Task 207 does not task the contractor.

### 207.2 TASK DESCRIPTION

Not applicable.

### 207.3 DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY

Not applicable.

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# TASK 208

## RELIABILITY CRITICAL ITEMS

### 208.1 PURPOSE

The purpose of Task 208 is to identify and control those items which require special attention because of complexity, application of state-of-the-art techniques, anticipated reliability problems, or the impact of potential failure on safety, readiness, and mission success.

### 208.2 TASK DESCRIPTION

208.2.1 An item shall be considered a critical item if it contains one or more single point failure modes. Additional critical items shall be identified based on the contractor's experience and using the criteria in paragraph 3.7 as guidance.

208.2.2 The contractor shall establish and maintain an effective method for identification, control and test of critical items from initial design through final acceptance. The method(s) the contractor uses for critical item control shall be described in the contractor's formal policies and procedures to ensure that all affected personnel such as design, purchasing, manufacturing, inspection, and test personnel are aware of the essential and critical nature of such items. Periodic reviews at PDR, CDR, Functional Configuration Audit (FCA), and Physical Configuration Audit (PCA), as a minimum, shall be used by the contractor and the acquisition activity to determine if additions or deletions to the critical item list and control plan(s) and procedures are warranted, and to assess the effectiveness of the critical item controls and tests. Each critical item control method and plan to be used shall be subject to on-going review and evaluation by the acquisition activity.

208.2.3 The critical item list shall include items having critically limited useful life such as maximum total operating time or operating cycles. The maximum allowable operating time or cycles of operation shall be clearly defined along with the elements of data and computational methods used in their derivation. The contractor shall maintain a record for each such item that contains its total operating time or number of equivalent operating cycles, starting with and including its initial functional testing, whether at the contractor's or supplier's facility. The operating time records shall become part of the acceptance documentation.

208.2.4 The contractor shall establish and maintain a current list of critical items. The list shall contain all critical items which have not been dispositioned or removed by the acquisition activity. The critical items list shall contain the following FMECA information, when Task 204 is contractually required:

a. The identification of the item under analysis, the same information described in paragraph 4.5.2 of MIL-STD-1629, and a statement as to whether or not it is a single point failure mode.

b. Citation of the pages or entry identifications of the FMECA that described the failure modes.

c. Statements identifying compensating features included in the design (e.g., extra safety margins), control methods (e.g., overstress testing, process controls, special checkout procedures), or other practices incorporated to minimize the occurrence of failures associated with critical items.

208.3 <u>DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY</u> (Reference paragraph 1.2.2)

Any data item to be delivered as a result of this task should be specified on a DD Form 1423. Applicable data items for this task are listed in Appendix E.

# 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 The contractor shall establish, maintain and implement procedures to determine by test and analysis, or estimation, the effects of storage, shelf-life, packaging, transportation, handling, maintenance and repeated exposure to testing on the design and reliability of a product. The results of this analysis shall be used to support design trade-offs, definition of allowable test exposures, retest after storage decisions, special handling, transportation, packaging, or storage requirements and refurbishment plans.

### 209.3 DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY (Reference paragraph 1.2.2)

209.3.1 The SOW should identify functional testing, storage, handling, packaging, transportation, and maintenance profiles. Applicable data items for this task are listed in Appendix E.

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# TASK 210

# DESIGN FOR RELIABILITY

## 210.1 PURPOSE

The purpose of Task 210 is to ensure use of techniques which have proven successful in achieving a reliable design.

## 210.2 TASK DESCRIPTION

210.2.1 The contractor shall give preference to hardware, software, and hardware designs that have performed successfully in the intended actual mission environment. Unproven designs shall be validated by analysis and test as part of the design process. The approved derating criteria, including radiation effects when applicable, shall be established for use by designers and deviations to the criteria shall require joint approval of the contractor's system engineering, parts engineering, and reliability managers. The contractor's electronic parts derating criteria for design shall be consistent with part derating policy in MIL-STD-1547. The contractor shall use part standardization, type and quantity minimization, stress derating, redundancy, fault isolation, single point failure minimization, and stress-strength analysis in his design. These program peculiar criteria shall be developed for and used by the designers.

210.2.2 The contractor shall ensure optimum application of all redundancy techniques (active, passive, and graceful degradation). Single point failure modes shall not be permited for mission critical components, except as provided in Task 204, paragraph 204.2.12.1, when applicable. Design for redundancy shall utilize independent paths of operation or communication and provide for a high degree of assurance of effective successful operation during intermittent failure modes.

210.2.3 The contractor shall perform a reliability analysis of the system as an integral part of the overall system engineering analysis. Criteria for the analysis shall include operational and support concepts, requirements, and environmental conditions. The results of these reliability analyses shall be used during design, development, and test to evaluate the achievement of the reliability design requirements. The contractor shall not compromise reliability or reliability related criteria such as maintainability, quality assurance, electromagnetic compatibility, electromagnetic interference, safety, or parts requirements in an attempt to exceed contractually specified performance criteria.

210.2.4 Whenever design trade-offs are performed, or engineering change proposals are generated, the contractor shall define the effects of the proposed change(s) on the reliability of the entire system. The details of the trade-offs involving system reliability and the results of any design change on reliability shall be evaluated, recorded, and reflected in the reliability analysis.

210.3 <u>DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY</u> (Reference paragraph 1.2.2).

Any data item to be delivered as a result of this task should be specified on a DD Form 1423. Applicable data items for this task are listed in Appendix E.

# SECTION 300

# DEVELOPMENT AND PRODUCTION TESTING TASKS

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TASK 301

ENVIRONMENTAL STRESS SCREENING (ESS)

301.1 PURPOSE

Test requirements for parts, components, and systems used in spacecraft and launch vehicles are specified in MIL-STD-1546, MIL-STD-1547, and MIL-STD-1540. Some of the requirements in these documents perform an environmental stress screening function. These standards appropriately tailored are included in a separate portion of the contract. The purpose of this task is to define reliability program functions related to environmental stress screening.

301.2 TASK DESCRIPTION

301.2.1 Environmental stress screening, including burn-in, shall be conducted on selected components and subassemblies to eliminate early and potential failures due to latent part defects, workmanship defects, undetected design defects, and undetected failure modes.

301.2.2 During development, subassemblies and components shall be identified and applicable ESS procedures shall be formulated. Key factors in the selection of items and ESS levels include development tests, past history on similar equipment, item technology, fabrication techniques, and FMECA results, when performed.

301.2.3 ESS shall be designed to stimulate relevant failures by stressing the item through application of environmental and operational stresses. When ESS planned levels exceed qualification test levels, an analysis shall be performed and justification provided prior to implementation or levels adjusted accordingly.

301.2.4 Upon approval of the proposed ESS procedures, a detailed ESS plan shall be prepared. The ESS plan shall include the following:

a. Identification of the items to be subjected to ESS.

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

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

d. Proposed ESS duration, including failure free time and maximum exposure time.

e. Criteria for removal of an item from ESS.

301.3 DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY (Reference paragraph 1.2.2)

Data items to be delivered as a result of this task should be specified on the DD Form 1423. Applicable data items for this task are listed in Appendix E.

# TASK 302

# RELIABILITY DEVELOPMENT GROWTH TEST (RDGT) PROGRAM

## 302.1 PURPOSE

Designs for long life and high reliability space systems require sufficient design margins to ensure long life. The limited number of systems produced and the relatively short development period preclude sufficient testing to identify marginal designs and hidden failure modes. The purpose of Task 302 is to conduct prequalification testing to provide a basis for resolving a majority of reliability problems early in the development phase, and to ensure adequate design margins appropriate to long-life, high reliability space systems.

## 302.2 TASK DESCRIPTION

302.2.1 Reliability development growth tests shall be conducted for the purpose of enhancing system reliability through the identification, analysis, and correction of failure modes, and the verification of corrective action effectiveness. Guidance for conducting RDGT is contained in MIL-STD-1635 and MIL-HDBK-189.

302.2.2 Reliability growth tests shall include application of environmental, power, and performance stresses sufficient to identify design weaknesses and to induce failure or demonstrate design margins. This generally requires stresses beyond operational design specifications. Test items shall include normal interface connections between assemblies and components, to ensure new failure modes are not introduced in system operation.

302.2.3 Reliability growth testing shall be integrated with the development testing specified in MIL-STD-1540. Items selected for RDGT shall include assemblies and components for which the design is new or operational history is inadequate to satisfy mission requirements.

302.2.4 An RDGT plan shall be prepared and shall include the following, subject to contracting officer approval prior to initiation of testing:

a. Test objectives and requirements, including growth model, growth rate, initial and final reliability values, and their rationale.

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

c. Test conditions including environmental, operations, and performance profiles, as applicable.

d. Test schedules and cross reference to development tests.

e. Procedures for corrective action.

f. Data recording and collection requirements.

302.3 <u>DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY</u> (Reference paragraph 1.2.2)

302.3.1 Failure reporting in accordance with Task 104, FRACAS, should be specified.

302.3.2 Recommended candidates for RDGT.

302.3.3 Any data item to be delivered as a result of this task should be specified on a DD Form 1423. Applicable data items for this task are listed in Appendix E.

# TASK 303

# RELIABILITY DEMONSTRATION

## 303.1 PURPOSE

The purpose of Task 303 is to demonstrate that the quantitative reliability requirements have been met. Although this task is included in the Development and Production Testing Section, it should be recognized that the reliability demonstration for spacecraft and launch vehicles is performed analytically using the reliability prediction, FMECA, item failure reports, and program test data.

## 303.2 TASK DESCRIPTION

303.2.1 The contractor shall implement and maintain a reliability test and demonstration program that is planned, integrated, and developed with the system and equipment test program, such as development testing, quality assurance testing, performance, flight testing, item testing, and maintainability demonstration, to avoid duplicate testing. This program shall include the requirements of this standard and receive acquisition activity approval prior to implementation. The program shall include all reliability testing and demonstration to be performed for the program. Tests shall be designed to make maximum use of reliability data from all sources. Unless otherwise specified by the contract, the contractor shall analytically demonstrate the achievement of minimum acceptable hardware reliability requirements as part of qualification. The analytical methods, assumptions and piece part failure rates to be used shall have specific approval of the contracting officer. The contractor shall use the results of program tests, Failure Modes, Effects and Criticality Analyses (FMECAs), when required, and item failure reports to qualitatively evaluate the demonstration results as part of the assessment of the item predictions.

303.2.2 The contractor shall identify to the contracting officer items which are candidates for reliability evaluation, reliability development growth testing or life tests. As a minimum, these shall include items that have limited documented history of previous usage to support the life requirements of the program. Reliability evaluation or life tests shall be performed as directed by the contracting officer. The contractor's reliability evaluation or life test plans shall be included in the Program Test Plan and be detailed with sample sizes, test duration, confidence level, test conditions, and accept-reject criteria as a minimum. The FMECA, when required, shall be used as an aid in the design of the test plans and procedures. Test results shall be used to ascertain the item's capability to comply with the program reliability requirements.

303.2.3 The results of contractor's functional and environmental testing of items during the design and development phases shall be analyzed to estimate achieved reliability, to provide confidence in the predicted reliability, and to provide feedback to support design changes that impact reliability. A log book shall be maintained for each item identified on the program equipment listing to record its operating times during assembly, test, and operation. The development testing program shall be used to confirm the following factors, down to the piece part level: adequacy of item selection, safety margins, parameter drift with time, failure modes, and establishment of human performance operation and maintenance variability criteria.

303.2.4 The contractor shall make use of statistical planning and analysis in the test program. This may include application of such methods as design of experiments, analysis of variance, and other methods applicable to design, development, production, and operational phases. Consideration should be given to the use of accelerated test techniques suitable to the equipment under test, provided the test results can be extrapolated to estimate mission reliability.

303.3 <u>DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY</u> (Reference paragraph 1.2.2)

303.3.1 Quantitative reliability requirements.

303.3.2 Any data item to be delivered as a result of this task should be specified on a DD Form 1423. Applicable data items for this task are listed in Appendix E.

## TASK 304

## PRODUCTION RELIABILITY ACCEPTANCE TEST (PRAT) PROGRAM

This task generally is not applicable to spacecraft and launch vehicle contracts.

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**APPENDIX A**

**APPLICATION GUIDANCE FOR IMPLEMENTATION OF MIL-STD-1543**

This appendix is not a mandatory part of this standard.

## 10. GENERAL

10.1 SCOPE. This appendix provides guidance for the selection of reliability tasks as they apply to various acquisition phases and is not to be construed as mandatory.

10.2 PURPOSE. This appendix is to be used to tailor the standard in the most cost-effective manner that meets established program objectives. Additional tailoring guidance and descriptions of the tasks and their function in a complete reliability program can be found in Appendix A to MIL-STD-785, "Reliability Program for Systems and Equipment Development and Production." In addition, Table A-1 is an application matrix guide for the program acquisition phases. The matrix should be used for general guidance since the tailoring constraints (paragraph 40.2) can seriously affect applicability of each task.

## 20. REFERENCED DOCUMENTS

| | |
|---|---|
| MIL-STD-781 | Reliability Testing for Development, Qualification, & Production |
| MIL-STD-785 | Reliability Program for Systems and Equipment Development and Production |

## 30. DEFINITIONS

Not applicable.

## 40. GENERAL APPLICATION REQUIREMENTS

40.1 ACQUISITION ACTIVITY RESPONSIBILITY. The acquisition activity needs to ensure that tailored reliability requirements are applied in contracts, statements of work, or requests for proposals, as applicable (reference paragraph 40.2).

40.2 TAILORING OF TASK DESCRIPTIONS AND DATA ITEMS. Applicable tasks are to be selected and task descriptions tailored as required by governing regulations and as necessary to meet program objectives based on equipment complexity, criticality, quantity, category, program type, magnitude and

TABLE A-1. Application Matrix Guide

| 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 | G(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 | G | G |
| 201 | RELIABILITY MODELING | ENG | G(1) | G(1) | G | GC |
| 202 | RELIABILITY ALLOCATIONS | ACC | G(1) | G | G | GC |
| 203 | RELIABILITY PREDICTIONS | ACC | S | G(1) | G | GC |
| 204 | FAILURE MODES, EFFECTS, AND CRITICALITY ANALYSIS (FMECA) | ENG | S | G(1) | G | GC |
| 205 | DESIGN CONCERN ANALYSIS (DCA) | ENG | NA | NA | G(1) | GC(1) |
| 206 | CIRCUIT AND ITEM STRESS ANALYSIS | ENG | S | S | G | GC |
| 207 | PARTS PROGRAM | ENG | S | S(2) | G(2) | G(2) |
| 208 | RELIABILITY CRITICAL ITEMS | MGT | S(1) | G(1) | G | G |
| 209 | EFFECTS OF FUNCTIONAL TESTING STORAGE, HANDLING, PACKAGING, TRANSPORTATION, AND MAINTENANCE | ENG | NA | G(1) | G | GC |
| 210 | DESIGN FOR RELIABILITY | ENG | S | G | G | GC |
| 301 | ENVIRONMENTAL STRESS SCREENING (ESS) | NA | S | G(1) | G(1) | G |
| 302 | RELIABILITY DEVELOPMENT GROWTH TESTING | ENG | NA | S(1) | G(1) | CG(1) |
| 303 | RELIABILITY DEMONSTRATION | ACC | NA | S(1) | G(1) | S(1) |
| 304 | PRODUCTION RELIABILITY ACCEPTANCE TEST (PRAT) PROGRAM | ACC | NA | NA | NA | S(1) |

ACRONYMS FOR TASK TYPE:
- ACC - RELIABILITY ACCOUNTING
- ENG - RELIABILITY ENGINEERING
- MGT - MANAGEMENT

ACRONYMS FOR PROGRAM PHASE
- S - SELECTIVELY APPLICABLE
- G - GENERALLY APPLICABLE
- GC - GENERALLY APPLICABLE TO DESIGN CHANGES ONLY
- NA - NOT APPLICABLE

FOOTNOTES:
(1) - REQUIRES TAILORED APPLICATION TO BE COST EFFECTIVE
(2) - MIL-STD-1543 IS NOT THE PRIMARY IMPLEMENTATION REQUIREMENT OTHER MIL-STDS OR STATEMENT OF WORK REQUIREMENTS MUST BE INCLUDED TO DEFINE THE REQUIREMENTS

funding, acquisition phase, and life cycle cost. The cost of imposing each requirement in this standard should be evaluated against the benefits that could be realized. The "DETAILS TO BE SPECIFIED BY THE ACQUISITION ACTIVITY" paragraph under each task description is intended for listing the specific details, additions, modifications, deletion, or options to the requirements of the task that should be considered by the acquisition activity when tailoring the task description to fit the program needs. Items annotated by an "(R)" are essential and shall be provided to the contractor for proper implementation of the task. All data items should be reviewed and tailored, as applicable, to ensure that the preparation instructions in the DID are compatible with task requirements as specified in the statement of work.

40.3 RELIABILITY PROGRAM OBJECTIVES:

a. CONCEPT phase: Specific values of reliability characteristics in operational terms are derived from generic reliability needs of the mission area. Quantitative reliability objectives are refined based on system level trade studies.

b. VALID phase: To require identification of critical parameters that impact reliability either by test or by analysis. A formal reliability program is required only if the system or equipment criticality or total acquisition cost suggests its need. Usually, the updating of reliability requirements within the design plan is sufficient. Updating can include test monitoring, failure analysis, and corrective action feedback.

c. FSED phase: A fully developed program does not necessarily contain all tasks of this standard but it should be capable of being independently evaluated to determine the effectiveness of the task in providing design assurance.

d. PROD phase: To maintain design integrity and to ensure that implementation of the design in production does not detract from its inherent reliability. Design changes and critical or special processes require evaluation and monitoring. The results of failure analysis, process trends and field feedback should be analyzed during the production phase and design and manufacturing corrections implemented as necessary.

## 50. TASK OBJECTIVES

### 50.1 TASK 101. RELIABILITY PROGRAM PLAN

a. CONCEPT phase: Generally not applicable unless hardware development, such as experiments, are involved.

b. VALID phase: To provide assurance that all requirements are planned and scheduled. Depending on the criticality and category of equipment, the program plan could be developed as a separate entity or with other test and design planning.

c. FSED phase: To establish a clearly identified reliability program including the necessary organizational authority to influence the achievement of reliability program milestones. A fully developed and controlled program, which includes reporting of status and problem areas to all levels of management, should be administered by the reliability organization. It is highly desirable that a single reliability contact point be established for all acquisition activity interfaces.

d. PROD phase: To continue functions of the reliability organization to the extent necessary to ensure that engineering changes or production processes do not degrade design reliability.

50.2 TASK 102. MONITOR AND CONTROL OF SUBCONTRACTORS AND SUPPLIER. This task is intended to minimize the risk of not achieving the required system reliability due to poor reliability of subcontracted supplies. The task requires contractor inclusion of allocated requirements in subcontracts and surveillance of subcontractor reliability activities. It should be noted that even if this task is not specified the prime contractor is responsible for the reliability of subcontracted supplies.

50.3 TASK 103. PROGRAM REVIEWS. Program reviews are not tailored by program phase but should be planned and scheduled as appropriate for the acquisition activity to review its status and results achieved. For major complex programs, separate Reliability Program Reviews should be required. When MIL-STD-1521 is specified as a compliance document in the SOW, appropriate tailoring of that document may preclude the need for this task.

50.4 TASK 104, DISCREPANCY AND FAILURE RECORDING, ANALYSIS AND CORRECTIVE ACTION AND TASK 105, FAILURE REVIEW BOARD.

a. CONCEPT phase: Not applicable unless hardware, such as an experiment, is to be fabricated as part of the contract.

b. VALID phase: To impose a formal failure reporting and corrective action system (FRACAS) to varying degrees depending on the expected volume of failures for the particular program and the criticality of major system components. If a reliability development test is imposed, the greatest benefit can be derived from failures encountered during that testing program through the use of a FRACAS.

c. FSED phase: To obtain maximum benefit from correction of failures encountered during any formal qualification or acceptance testing. Contractor procedures may be used prior to formal qualification or acceptance testing.

d. PROD phase: To obtain maximum benefit from correction of failures encountered during any manufacturing tests or acceptance tests. Provision should be made by the acquisition activity to ensure that the user provides adequate failure information to assist the corrective action process.

50.5 TASK 201, RELIABILITY MODELING

a. CONCEPT and VALID phases: Applicable at the system level to facilitate reliability analyses and trade studies.

b. FSED phase: The math model is necessary to facilitate reliability allocations, prediction, and FMECA. The initial math model may be to the subsystem level, with the model progressing to the component and part level as the design evolves and becomes firm.

c. PROD phase: Normally, only major design changes would require a revision to the R model.

50.6 TASK 202, RELIABILITY ALLOCATIONS

a. CONCEPT and VALID phases: Applicable at the system level to facilitate reliability analyses and trade studies.

b. FSED phase: The reliability allocation should be performed early in the FSED phase to serve as a baseline requirement for designers and subcontractors.

c. PROD phase: Not applicable.

50.7 TASK 203, RELIABILITY PREDICTION

a. CONCEPT phase: Limited to functional levels of design. Details are not normally defined at this stage of development.

b. VALID phase: Fully applicable.

c. FSED phase: Fully applicable.

d. PROD phase: Reliability Prediction is restricted to significant Engineering Change Proposals.

50.8 TASK 204, FAILURE MODES EFFECTS AND CRITICALITY ANALYSIS. The FMECA is potentially one of the most beneficial and productive tasks in a well structured reliability program. Since individual failure modes are listed and evaluated in an orderly organized fashion, the FMECA serves to verify design integrity, identify and quantify sources of undesirable failure modes, and document the reliability risks. The FMECA is an essential design evaluation procedure which should not be limited to the phase traditionally thought of as the design phase (FSED). When the criticality analysis (Task 102, MIL-STD-1629) is required, the quantitative or qualitative method should be specified. Whenever possible, the quantitative method using probability of occurrence rather than criticality number should be specified. The specific FMECA tasks should be selected and applied for greatest cost effectiveness in accordance with the type and phase of the program. Provisions (sections, paragraphs or sentences) not required for the specific application should be excluded.

a. CONCEPT phase: FMECA is performed to functional levels of design.

b. VALID phase: FMECA is performed to functional levels of design and system determined to be critical.

c. FSED phase: Fully applicable, but tailored to be compatible with program requirements.

d. PROD phase: FMECA update may be necessary for significant Engineering Change Proposals and based on test results or on-orbit performance.

50.9 TASK 205. DESIGN CONCERN ANALYSIS (DCA)

a. CONCEPT and VALID phases: Not applicable.

b. FSED phase: DCA should be scheduled and completed concurrently with the design effort.

c. PROD phase: DCA is restricted to update due to extensive engineering changes or if system deficiencies have been identified by other means.

50.10 TASK 206. CIRCUIT AND ITEM STRESS ANALYSIS

a. CONCEPT and VALID phase: Applicable when hardware, such as experiments, are developed under the contract.

b. FSED phase: Fully applicable.

c. PROD phase: Applicable only to Engineering Change Proposals.

50.11 TASK 207. PARTS, MATERIALS AND PROCESSES (PMP) PROGRAM

a. CONCEPT phase: May be fully applicable when hardware, such as an experiment, is required to be developed.

b. VALID phase: To continue involvement in component application trade-offs and development of design application criteria. Planning should be developed for full implementation during full scale development.

c. FSED phase: Fully applicable.

d. PROD phase: Fully applicable.

50.12 TASK 208. RELIABILITY CRITICAL ITEMS

a. CONCEPT phase: Restricted to systems element consideration.

b. VALID phase: To establish a control mechanism within design planning where critical items are identified.

c. FSED phase: Fully applicable.

d. PROD phase: Continue critical item controls defined in the critical item control plan.

50.13 TASK 209, EFFECTS OF FUNCTION TESTING, STORAGE, HANDLING, PACKAGING, TRANSPORTATION, AND MAINTENANCE

a. CONCEPT and VALID phase: Applicable if hardware is developed.

b. FSED phase: Fully applicable. Requirements and controls should be developed and implemented. Particular emphasis should be placed on this task when space vehicle storage is anticipated.

c. PROD phase: Implement controls and procedures established in the development phase.

50.14 TASK 210, DESIGN FOR RELIABILITY

50.14.1 Design Techniques

a. CONCEPT phase: To be considered to the extent necessary to support preliminary design and trade studies.

b. VALID phase: To emphasize those techniques which involve basic design characteristics that could have a significant impact on the reliability of the final design. Because of the fluidity of the design in this phase, caution is advised against prematurely requiring application of techniques which may have to be repeatedly revised during the design evolution. Tasks which fall into this category include but are not limited to such techniques as worst-case analysis and parameter variance analysis.

c. FSED phase: The final baseline design destined for production should be subjected to reliability design analysis through application of appropriate design techniques. Therefore, in this phase, maximum application of such techniques is suggested, consistent with a cost-benefit evaluation of each technique and the potential impact on system performance, reliability, producibility, and ultimate life-cycle cost.

d. PROD phase: To be restricted to only those cases where design modifications are implemented or where necessary to support engineering failure investigations.

50.14.2 **Reliability Analysis**. The depth of this task increases as the program progresses through development. This task is applicable to CONCEPT, VALID, and FSED phases; it has limited application to the PROD phase except as appropriate when changes in function occur.

## 50.15 TASK 301, ENVIRONMENTAL STRESS SCREENING (ESS).

a. CONCEPT and VALID phases: Not applicable.

b. FSED phase: With the limited quantity of test items, it is difficult to identify all design and workmanship defects prior to production of flight hardware. ESS should be applied to programs and hardware on a selective basis, particularly where lower level equipment failures can cause significant rework and retest at higher levels. During this phase equipment and test levels should be selected and defined for ESS to screen out workmanship, design, and part failures.

c. PROD phase: The approved tests defined during FSED should be conducted. Criteria should be established for removing items from ESS or reducing test levels as design and production matures.

## 50.16 TASK 302, RELIABILITY DEVELOPMENT GROWTH TESTING.

a. CONCEPT phase: Not applicable.

b. VALID phase: Consider a test, analyze, and fix approach to reliability testing to uncover weaknesses in design approaches that were not previously detected by engineering analysis or testing. This testing consists of a sequence of tests, analyzing all failures, incorporating corrective action, and retesting to provide a basis for program decisions.



limited number of systems produced and the relatively short

c. FSED phase: A dedicated test, analyze, and fix approach to reliability testing should be imposed during this phase of acquisition cycle. This test should be designed, utilizing dedicated samples and sufficient test time, to uncover design deficiencies not detected during previous testing or analyses.

d. PROD phase: Selectively applicable when design changes require reliability growth in the hardware.

50.17 TASK 303, RELIABILITY DEMONSTRATION

a. CONCEPT phase: Not applicable.

b. VALID phase: Not applicable.

c. FSED phase: To provide confidence that the equipment design meets or exceeds program objectives. The test components used for this demonstration-analysis shall be the best available representation of the production configuration. The test-analysis also serves to confirm the effectiveness of corrective actions and provide a statistical assessment of program status for the production decision process.

d. PROD phase: To provide confidence by sampling and combining the equipment test to ensure that the equipment reliability continues to meet or exceed program objectives and was not degraded to an unacceptable level by the production process.

50.18 TASK 304, PRODUCTION RELIABILITY ACCEPTANCE TEST (PRAT) PROGRAM. Generally not applicable. If appropriate for a specific program, Task 304 of MIL-STD-785, "Reliability Program for Systems and Equipment Development and Production," may be used, or MIL-STD-781, "Reliability Testing for Development, Qualification, & Production," may be applied directly.

## APPENDIX B

## SNEAK ANALYSIS FUNCTIONAL CLUE LIST

This appendix is not a mandatory part of this standard.

1. Do functions perform as intended?
2. Are all functions and grounds compatible with the power sources?
3. Is power available when required to activate a function?
4. Are connected grounds compatible?
5. Are connected power sources from different power buses, i.e., is there a potential power-to-power tie?
6. Can any function be activated inadvertently or at incorrect times?
7. Are there undesired effects when a current or energy path is unintentionally opened or closed?
8. Can any combination of functions be activated by an unintended current or energy path?

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APPENDIX C

DESIGN CLUE LIST

This appendix is not a mandatory part of this standard.

SNEAK PATHS

1. Are signals apparently routed to unintended places? Is there an apparent reversal of polarity or phase between signals?

2. Can an operational amplifier be driven into saturation unintentionally?

3. Are totem pole outputs of digital devices connected together?

4. Do circuits containing symmetry have any asymmetric elements or paths?

5. Are grounds mixed in the same circuit?

6. Are digital circuitry, relays, or squibs on the same ground?

7. Is the isolation inadequate between tied power sources of different potential?

8. Are power supply and associated grounds at different reference points?

9. Are there any undesired capacitor discharge paths?

10. Are there momentary undesired current paths present during change of state or switching circuits?

SNEAK TIMING

11. Do circuits experience unintended modes or false outputs during power-up?

12. Do digital signals sharing a common source and load split and later recombine?

13. Are consecutive digital devices powered from different supplies?

14. Are noise margin limits exceeded for digital devices?

15. Do resistor-capacitor networks in digital circuits provide the required characteristics, such as pulse width and switching speed?

16. Do large resistor-capacitor time constants cause excessive rise or fall times in switching circuits?

17. Are there momentary undesired current paths during change-of-state of switches?

18. Do relay coils have a single standard diode with a zener diode in series for transient suppression?

19. Does high output impedance of transistor-to-transistor logic (TTL) devices cause an excessive resistor-capacitor time constant?

20. Are there any ground paths to transistor-to-transistor logic (TTL) device inputs (momentary or otherwise) which can turn the device on?

21. Does turn-on, turn-off, or open-close timing of any device cause a problem in its application?

22. Are there timing gaps (break-before-make) or overlaps (make-before-break) in switching circuits?

23. Are command lines adjacent to power line?

24. Does the capacitance of a line cause excessive "skew" of the signal in it?

SNEAK INDICATIONS

25. Does an indicator monitor a command of a function rather than the function itself?

26. Does an indicator circuit depend upon the function it monitors for proper operation?

27. Does a load perform an undesired function?

28. Can a press-to-test circuit energize a system?

SNEAK LABELS

29. Are all labels compatible?

30. Does the label reflect the true function?

# APPENDIX D

## POTENTIAL DESIGN CONCERNS

This appendix is not a mandatory part of this standard.

1. Do uncommitted switching device outputs drive other switching circuitry?

2. Is there a ground-to-output on transistor-to-transistor logic (TTL) devices?

3. Do compatibility requirements differ at the interface of two integrated circuit technologies?

4. Is fan-out of digital devices exceeded?

5. Are input voltage or current requirements to semiconductor devices exceeded?

6. Is any circuitry unused or unnecessary?

7. Are any relay coils unsuppressed?

8. Are any test points unprotected, i.e., lacking isolation resistance?

9. Do amplifiers or comparators have capacitors greater than 0.1 microfarads connected from input to ground or as feedback elements without series limiting resistance?

10. Do comparators have capacitors greater than 0.1 microfarads connected from output to ground without series limiting resistance?

11. Do operational amplifier inputs see unequal impedance?

12. Do spare inputs of integrated circuit devices have open circuit inputs?

13. Do complimentary metal oxide semiconductor (CMOS) devices have inputs feeding off the circuit card without pull-up or pull-down resistors?

14. Do large scale transistor-to-transistor logic (LSTTL) devices have spare inputs connected to used inputs of the same gate?

15. Are differentiator circuits used?

16. Do integrated circuit devices or transistor-to-transistor logic (TTL) devices have any open inputs or gates.

17. Do operational amplifiers lack bias current resistors or have resistors with improper values?

18. Are any unused operational amplifiers not in a unity gain configuration with all inputs grounded?

19. Do relay coils have single standard diodes for transient suppression?

20. Is the noise margin less than 0.5 volts at inputs for large scale type logic devices?

21. Is a transistor operating in the saturated region?

22. Are any digital devices improperly biased?

23. Do any capacitors have maximum charge or discharge currents that can damage other components?

24. Is $V_{in}$ of an integrated circuit greater than $V_{CC}$?

25. Are any integrated circuit inputs or outputs unsuppressed?

26. Is available energy insufficient to "blow" a squib component?

27. After firing, can the squib component short or open?

28. Is static energy protection for squib components lacking?

29. Is "no-fire" current protection lacking for squib components during checkout test?

30. Is a squib component without a current limiting resistor?

31. Can the forward resistance of a diode affect charging and discharging times?

32. Are there potential reverse voltages which can damage tantalum capacitors?

33. Can a semiconductor controlled rectifier turn on prematurely?

34. Are lamps without isolation fuses?

35. Can "cross-talk" adversely affect signals in adjacent wires?

36. Are power switching transistors subject to damage of inductive switching spikes?

DRAWING ERRORS

37. Are any devices shown with power, signal, or ground connections missing?

38. Do parts, components or interfaces on a drawing disagree with other drawings that represent different indenture levels or are continuation sheets?

39. Does the parts list disagree with the drawings?

40. Is a tantalum capacitor shown connected incorrectly?

41. Is there a lack of dynamic stability?

42. Are there deficient parts as evidenced by:

    a. Failures of a generic or chronic character,
    b. Limited capability substitute parts,
    c. Over stressed parts?

43. Is there a single multi-pole relay carrying redundant functions?

44. Is there unintended thermal coupling between high dissipation or heat sensitive elements?

45. Are harnesses, connectors, and tie points shared in common by otherwise redundant paths?

46. Are there sympathetically induced failures such as common heat sink and electrical path for transistors, rectifiers, and blocking diodes?

47. Are redundancy paths integrated into a common multi-layer printed circuit board?

48. Is redundancy negated due to sneak paths embodied in sensors or signal processing circuits?

49. Does command logic and execution hardware form a single point failure site for pyrotechnic or ordnance devices?

50. Is there sharing of fuses?

51. Is there sharing of redundant items, such as:

    a. Common power supplies or converters,
    b. Common power lines and returns,
    c. Jumpered signal points,
    d. Common printed wire traces,
    e. Common connectors and pins?

52. Are multi-function parts, such as dual transistors, dual integrated circuits, or quad integrated circuits shared in redundant paths or alternate modes of operation?

53. Are printed circuit board traces and wires properly derated?

54. Are there common line decoupling capacitors?

55. Are there single line decoupling capacitors or blocking diodes?

56. Could there be structural or mechanical failure of housings (and support structure) containing redundant items?

57. Are there microwave device failure modes which degrade electrical performance of companion redundant devices via poor isolation, high voltage standing wave ratio, or noise generation?

58. Are there common jacks, pins, and connectors on splitters or dividers upstream from redundant items?

59. Can a failure in one experiment result in spacecraft failure in multiple payload spacecraft?

60. Is there exposure of redundant elements to a single failure stimulus?

61. Is there an inability to detect a failed item?

62. Can erroneous commands be induced by human error or software?

63. Can test equipment or other AGE induced failures?

64. Are there overstress mechanical failures?

65. Are there overstress electrical failures?

66. Are there overstress thermal or thermal cyclic failures?

67. Are there corrosion, electrochemical, or physicochemical failures?

68. Are there contamination, plume impingement, outgassing and related failures?

69. Have the effect of body bending on control and stability been properly addressed?

70. Have the effect of fluid sloshing been properly addressed?

71. Have the inertial and coupling effects of masses been properly addressed?

72. Is there adequate venting?

73. Has the possibility of multipacting breakdown been properly addressed?

74. Has the possibility of corona breakdown been properly addressed?

75. Has the possibility of fatigue been properly addressed?

76. Is there inadequate shielding or improper parts application that may lead to radiation damage?

77. Are there microwave material or construction deficiencies resulting in generation of intermodulation products (IMP).

78. Can events which terminate or seriously degrade performance or which constitute a safety hazard be caused by fewer than two distinct actions?

79. Are there inadequate keying, clocking, size variations, or harness installations permitting crossmating of printed circuit boards, electrical, hydraulic, ordnance, or other connectors?

80. Can there be a repeat of past design weaknesses due to inadequate review of available histories of similar equipments and designs?

81. Can there be electromagnetic compatibility or electromagnetic interference failures?

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# APPENDIX E

## APPLICABLE DATA REQUIREMENTS

This appendix is not a mandatory part of this standard.

10. CONSIDERATION OF DATA REQUIREMENTS.

The following data requirements should be considered when this standard is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/provided and that the DID's are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DOD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

| Reference Task | DID Number | DID Title | Suggested Tailoring |
|---|---|---|---|
| 101 | DI-R-7079 | Reliability Program Plan | none |
| 102 | DI-R-7079 | Reliability Program Plan | none |
| 103 | DI-A-7088 | Conference Agenda | none |
| | DI-A-7089 | Conference Minutes | none |
| 104 | DI-RELI-80255 | Report, Failure Summary and Analysis | none |
| | DI-QCIC-80125 | ALERT/SAFE ALERT | none |
| | DI-QCIC-80126 | Response to an ALERT/SAFE ALERT | none |
| | DI-RELI-80253 | Failed Item Analysis Report | none |
| 201 | DI-RELI-80686 | Reliability Allocations, Assessments, and Analysis Report | none |
| 202 | DI-RELI-80686 | Reliability Allocations, Assessments, and Analysis Report | none |

(continued from previous page)

| Reference Task | DID Number | DID Title | Suggested Tailoring |
|---|---|---|---|
| 203 | DI-RELI-80686 | Reliability Allocations, Assessments, and Analysis Report | none |
| 204 | DI-R 7086 | FMECA Plan | none |
| | DI-RELI-80687 | Report, Failure Mode and Effects Analysis (FMEA) | none |
| 205 | DI-RELI-80686 | Reliability Allocations, Assessments, and Analysis Report | none |
| 206 | DI-R-7084 | Electronic Parts/Circuits Tolerance Analysis Report | none |
| 208 | DI-RELI-80685 | Critical Items List | none |
| 209 | DI-RELI-80686 | Reliability Allocations, Assessments, and Analysis Report | none |
| 210 | DI-RELI-80686 | Reliability Allocations, Assessments, and Analysis Report | none |
| 301 | DI-RELI-80249 | Environmental Stress Screening Report | none |
| | DI-RELI-80251 | Reliability Test and Demonstration Procedures | none |
| 302 | DI-RELI-80250 | Reliability Test Plan | none |
| 303 | DI-RELI-80250 | Reliability Test Plan | none |
| 304 | DI-RELI-80251 | Reliability Test and Demonstration Procedures | none |
| | DI-RELI-80252 | Reliability Test Reports | none |

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



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*(See Instructions – Reverse Side)*

**1. DOCUMENT NUMBER**
MIL-STD-1543B(USAF)

**2. DOCUMENT TITLE**
Reliability Program Requirements for Space and Launch Vehicles

**3a. NAME OF SUBMITTING ORGANIZATION**

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

**4. TYPE OF ORGANIZATION** *(Mark one)*

- ☐ VENDOR
- ☐ USER
- ☐ MANUFACTURER
- ☐ OTHER *(Specify)*: ______

**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

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