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MARSHALL POLICY DIRECTIVE

QD01

MSFC RELIABILITY AND MAINTAINABILITY PROGRAM FOR SPACE SYSTEMS

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DOCUMENT HISTORY LOG

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1. PURPOSE

To establish policy, responsibilities and procedures for planning, establishment, and implementation of the Reliability and Maintainability (R&M) Program processes for Marshall Space Flight Center (MSFC) programs and projects to:

a. Ensure that appropriate value-added R&M engineering activities and processes are implemented throughout the program and project life cycle that positively influence the system design development;

b. Ensure that R&M engineering activities, processes and data are fully integrated with the program and project systems engineering process including supportability and other related processes; and,

c. Ensure timely and continuous assessment of the progress toward achieving R&M requirements, including identification of areas for improvement.

2. APPLICABILITY

This Directive applies to MSFC program and project offices having responsibility for the design of manned and unmanned space flight projects and payloads. To the extent practical, this directive shall be applicable to the existing programs and projects. This Marshall Policy Directive (MPD) does not apply to facility projects.

3. AUTHORITY

NPD 8700.1, "NASA Policy for Safety and Mission Success"

4. APPLICABLE DOCUMENTS

NPD 8720.1, "NASA Reliability and Maintainability Program Policy"

5. REFERENCES

a. NASA-STD-8729.1, "Planning, Developing and Managing an Effective Reliability and Maintainability (R&M) Program"

b. MIL-HDBK-470, "Designing and Developing Maintainable Products and Systems"

c. NSTS 5300.4 (1D-2), "Safety, Reliability, Maintainability and Quality provisions for the Space Shuttle Program"

d. NPR 8715.3, "NASA Safety Manual"

e. NPR 8000.4, "Risk Management Procedures and Guidelines"

f. SAE ARP4761, "Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment"

g. NPD 7500.1, "Program and Project Logistics Policy"

h. MIL-HDBK-502, "Acquisition Logistics"

6. DEFINITIONS

a. Reliability. Reliability is a performance characteristic of a product or a system. It is defined as: "The probability of successful operation of a product or a system for a specified period of time under specified conditions and environments of operation." Three items are vital for reliability:

(1) Successful operation,

(2) Period of time, and

(3) The conditions of operation.

b. Maintainability. A measure of the ease and rapidity with which a system or equipment can be restored to operational status following an anomaly and/or failure.

c. Maintenance. The act of diagnosing and physically repairing or preventing equipment anomalies and/or failures.

d. Supportability. Supportability is one of the key design and performance functions that identify the logistics resources required to support the system during its operating or useful life.

It is a systems engineering discipline that integrates the reliability, availability, maintainability, and logistics analyses into a cohesive evaluation of the total system design to ensure cost effective support of the total system operations. The goal of supportability engineering is to minimize a system's life cycle support resources while satisfying its supportability criterion in a cost-effective manner.

NOTE: Refer to NASA-STD-8729.1 for a comprehensive list of definitions of R&M terminology used in this MPD.

7. POLICY

a. Reliability and Maintainability program shall be planned, established, documented and implemented for all programs and projects during all phases of development and operations based on mission requirements and the operational environment per NPD 8720.1A using the guidance of NASA-STD-8729.1. These requirements shall be imposed through inclusion of proper provisions in program and project plans, specifications, and statements of work.

b. Following requirements for the R&M program shall be imposed through inclusion of proper provisions in program and project plans, specifications, and statements of work.

(1) System R&M design and operational requirements (quantitative and qualitative).

(2) System maintenance concept.

(3) Requirements and tasks for R&M engineering, analysis and testing (including hardware, software and human elements).

(4) Timely and continuous assessment of the progress towards achieving the R&M requirements including identification of areas of improvement.

(5) Integration of R&M processes, analytical activities and data with systems engineering, engineering, systems safety, risk management, and other processes, assessments and analysis including, but not limited to quality, logistics(supportability), probabilistic risk assessment (PRA), life cycle cost, configuration management and operations (maintenance).

c. Reliability and Maintainability engineering activities are applicable to all project phases. Since the goal of these activities is to influence the system design, special emphasis should be placed on imposing this Directive at the formulation phase in order to be the most cost effective.

8. RESPONSIBILITIES

It is vital for Program, Engineering, Systems Engineering, and S&MA personnel to select suitable R&M processes/activities from a representative R&M processes list at Appendix A, to meet the program and project's mission safety, reliability, maintainability and availability requirements per Design and System's Level I, II, III applicable requirements.

a. Safety and Mission Assurance (S&MA) Directorate is responsible for:

(1) Ensuring overall implementation of the Reliability and Maintainability program using this Directive in close coordination with the program and project office.

(2) Assisting the program and project offices in the determination of the appropriate R&M program activities/tasks, qualitative and quantitative goals, as applicable, to meet the specific program and project needs, using the guidelines of NASA-STD-8729.1.

(3) Acting as the focal point for coordinating and providing comments on any contractor-provided R&M data (plans, requirements, assumptions, groundrules, etc.) which require such action.

(4) Supporting the programs and projects with review of contractor-provided R&M data to ensure that the contractor has implemented the R&M requirements per approved plans, guidelines, and procedures.

(5) Performing R&M analyses such as Failure Modes and Effects Analysis (FMEA)/Critical Items Lists (CIL), Reliability Predictions, Probabilistic Risk Analysis (for complex systems), Maintainability Analysis for in-house designed projects in close coordination with systems safety analysis and design analysis efforts.

(6) Preparing the R&M inputs to Project Plans and S&MA Plans for in-house programs/projects.

(7) Evaluating design changes for impact on R&M from an assurance standpoint as well as to provide the independent oversight to management.

(8) Assisting the program and project with evaluation of problem reports from problem reporting and corrective action system or

flight experience or other anomalous conditions, potentially impacting R&M to assure contractor compliance to reporting and assessment requirements. The Problem/Failure trending processes shall be implemented and pursued, as appropriate, to proactively identify potential program risks.

(9) Submitting appropriate documents for inclusion into the R&M data interchange portion of the Government-Industry Data Exchange Program (GIDEP) and the associated reporting requirements.

(10) Participate in verification and validation of design qualification analysis and testing tasks to ensure suitability of the design to meet requirements with sufficient safety margins. Reliability and maintainability models should also be verified and validated for underlying assumptions.

b. The Systems Engineering is responsible for:

Develop various program and project specific performance requirements such as mission requirements, product/system performance requirements, reliability-maintainability and supportability (RMS) requirements, safety requirements, quality requirements, operations requirements and appropriate verification and validation checkpoints and screens to effectively meet program and project requirements. These requirements are recommended to be assessed and finalized based on input from associated functional groups and departments as part of the integrated systems design effort.

c. The Engineering Directorate is responsible for:

(1) Ensure that the hardware and software design efforts are pursued with due considerations for designing-in reliability, maintainability and supportability as part of integrated design strategy.

(2) Integrated product team (IPT) approach or other cross-functional team groups with right expertise should be utilized to enhance the integrated system design process for all projects and programs.

(3) Develop the program and project Supportability concepts and plans, maintain the resultant databases, and provide sustaining engineering of the supportability engineering aspects for systems developed by MSFC

(4) Ensure that R&M data utilized in supportability analyses has been coordinated with S&MA.

d. The Responsible Program and Project Office is responsible for:

(1) Integrating all R&M activities with the associated design and operations functions and associated program and project safety, quality assurance, risk management, and logistics (including maintenance) activities.

(2) Ensuring the implementation of programmatic and technical R&M requirements as defined by S&MA in all appropriate statements of work and specifications.

(3) Establishing a maintenance concept early in the system development and ensuring that compatibility is sustained among system design, maintainability, and integrated logistics support.

(4) Establishing and maintaining a data collection system such as problem reporting and corrective action system that provides a basis for generating information and trending to evaluate R&M performance throughout the system's life cycle.

(5) Establishing closed loop corrective action and improvement system using metrics and other information systems to capture the effectiveness of these processes.

(6) Ensure that NASA shall get full access to all the contractor processes, tools and analysis and the analysis shall be current per program requirements and delivered to NASA for evaluation and approval as appropriate.

e. Program and project managers are responsible for the following:

(1) Integrating all R&M activities with the associated design and operation functions and associated program/project safety, quality assurance, risk management (including probabilistic risk assessment), and logistics (including maintenance) activities.

(2) Identifying the organization(s) that will maintain the R&M data for the lifetime of the system and coordinating with the Center S&MA functional manager to ensure that R&M data is available for use as heritage data.

(3) Arrange and provide funding to support R&M program as defined for the program and project or alert the S&MA Office that the budget levels will not support implementation of all requirements.

(4) Arranging scheduling and conducting design and program reviews, arranging distribution of review packages, and coordinating review issues.

(5) Use and distribute lessons learned to enhance the probability of mission success and establish recurrence control through a closed-loop corrective/preventive action system

(6) Facilitating in getting the R&M data for government-furnished property (GFP), if available.

(7) Establishing and implementing a system with the project contractor that will:

(a) Monitor and verify the achievement of R&M requirements with a well defined R&M roadmap based on realistic goals. Project and Program progress shall be monitored/measured using and a well defined yardstick to assess variances. Suitable measures shall be taken to comply with requirements, if significant/ serious variances are identified.

(b) Identify, assess, track, and report problems occurring during system operations that are attributable to system, subsystem, or design characteristics.

NOTE: There should be no duplication with the problem reporting and corrective action/problem assessment system already in place under S&MA. One system for all problems should suffice.

(c) Ensure that design changes are made to systems, subsystems, and components to enhance R&M characteristics consistent with program requirements and guidelines.

f. The Director, Procurement Office, is responsible for ensuring that programmatic and technical R&M requirements are included in requests for proposals and resultant contracts (including Statement of Work) for all space flight systems and payloads to the extent requested by the initiating project office in close coordination with S&MA.

9. RECORDS

None

10. MEASUREMENT

None

11. CANCELLATION

MPD 8720.1 dated December 27, 1999

Original signed by
Axel Roth for

David A. King
Director

APPENDIX A

Key R&M and Engineering Activities, Processes and Systems

System design for a complex project can be enhanced using the following integrated Design-for-Reliability (DFR) and associated engineering analysis and processes. S&MA and Program office shall select appropriate R&M processes and analysis after assessing the complexity, mission profile, safety, reliability and availability requirements of a particular project and program. As part of integrated system design effort, engineering shall provide appropriate analysis and test results [for the activities marked with stars (*)], to support the R&M tasks to meet program and project goals.

I **Key Reliability Associated Activities/Processes/Systems**

i. Reliability Block Diagram (RBD)
ii. Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL)
iii. Reliability Predictions
iv. Probabilistic Risk Assessment (PRA)
v. Reliability Growth Program
vi. *Worst Case Analysis for electronic and mechanical systems
vii. *Testability Analysis
viii. *EEE Parts Management and Control
ix. *Electrical/Electronic Parts Stress Analysis (PSA)
x. *Limited Life Items management and control
xi. GIDEP ALERT System
xii. *Thermal Stress Analysis
xiii. *Structural Stress Analysis
xiv. Reliability Modeling Tools (including software selection)
xv. *Probabilistic Design Analysis(PDA)
xvi. *Sneak Circuit Analysis (SCA)
xvii. Qualification of Design
xviii. *Simulation and Sensitivity Analysis
xix. Reliability Trade Studies
xx. Process Control to minimize process variations
xxi. Fault Tree Analysis (FTA)
xxii. *Environmental Stress Screening (ESS)
xxiii. *Highly Accelerated Life Testing (HALT)
xxiv. *Highly Accelerated Stress Screening (HASS)
xxv. Comprehensive Problem Reporting and Corrective Action (PRACA) System and Trending
xxvi. Verification and Validation (V&V) of various models, analysis and systems for their accuracy,

assumptions, ground rules and validity to meet system's mission profile.

II **Key Maintainability Activities/Processes/Systems**

i. *Details of the planned process for identification of key Line Replaceable Units (LRU) to minimize life cycle cost along with ground rules and assumptions and the maintenance levels
ii. Maintenance Actions List
iii. Assessment of Mean Time to Repair (MTTR) for each of LRU, subsystem and system.
iv. *System, subsystems and key LRU's turn around time (TAT)
v. *Testability Analysis
vi. *Limited Life Items management and control
vii. *Reliability Centered Maintenance (RCM)
viii. Maintainability Trade Studies
ix. Availability Analysis
x. Identification of simulation tools for maintainability analysis