APOLLO SPACECRAFT RELIABILITY PROGRAM CONTROL — AN IMPORTANT ASPECT IN MAINTAINING A BALANCED RELIABILITY PROGRAM

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ABSTRACT

The paper outlines reliability program control methods relating to reliability task derivation, organizational reliability responsibilities, reliability milestones, reliability organization manning, and the concept of closed-loop management control systems for task implementation.

Methods and techniques are discussed with particular attention to the Apollo spacecraft reliability program. Typical problems encountered in the Apollo spacecraft reliability program are briefly discussed.

INTRODUCTION

NASA policy dictates that "every possible practical means be employed to achieve high system reliability at the earliest stage of system development." Frequent discussions of the disciplines required to assure reliable hardware have taken place over the years by technical personnel. Inevitably, the complexities of research and development (R and D) programs can lead to "after-the-fact" reliability programs if attention is not given to adequate control early in program development. For this reason, reliability program control methods were developed and used in the Apollo spacecraft program with specific attention given to:

1. Reliability tasks based on NASA Reliability Publication NPC 250-1 entitled "Reliability Program Provisions for Space System Contractors"
2. Organizational reliability responsibilities
3. Reliability outputs and milestones
4. Reliability manning indexes
5. Closed-loop management control systems for reliability task implementation.

With the recognition of reliability as a vital factor in the development of the Apollo spacecraft, emphasis was placed on the accomplishment of reliability tasks on a timely basis. Particular attention has been given to first-article high reliability and to exploitation of man-in-the-loop.

Organizational Responsibilities

Since reliability organizations have many responsibilities, many of which appear redundant rather than supplementary, it was mandatory to define the relative responsibilities of the Apollo contractors to avoid potential management problems.

Reliability Funding

The funding approach used in the Apollo spacecraft reliability program provides a reliability budget for only the reliability organization. The intent is to plan a total reliability program, with the reliability organization playing a "check-and-balance" role to assure that reliability disciplines are employed by all organizational elements.

Management Control Systems

With the development of complex manned spacecraft, the requirement for a well-organized management becomes mandatory. Because poor communications and lack of management control systems can give rise to unreliable hardware, the emphasis in Apollo spacecraft reliability organizations has been to develop and maintain a system that enhances efficient distribution and analysis of data and participates in program impact type tasks.

Reliability Skills

Although adequate program control measures are essential to a balanced reliability program, the importance of adequate skills and a motivated staff cannot be overemphasized, because these are essential to the development of reliable spacecraft.

An amplification of the above points, and methods and techniques for their implementation, are discussed in subsequent sections of the paper.

ELEVEN BASIC RELIABILITY TASKS

The need for compatible reliability program tasks was recognized. Basic reliability tasks were developed using the NASA Reliability Publication NPC 250-1 as a guideline. The derivation of these tasks, together with their negotiation, has proven essential to efficient communications with the Apollo spacecraft contractors, and in essence provides the framework for planning the entire reliability program. All of the essential reliability disciplines are included as a part of one or more of these tasks, which are listed below:

1. Reliability program management
2. Design specifications
3. Reliability apportionment, prediction, and assessments
4. Failure mode, effect, and criticality analysis
5. Maintainability
6. Design reviews
7. Failure reporting and corrective actions
8. Parts and materials program
9. Test planning and monitoring
10. Reliability indoctrination and training
11. Reliability documentation

A basic task-by-task boilerplate narrative is provided the contractor for use as a generic guide. From this boilerplate, a mutually acceptable revision is prepared by the Apollo spacecraft contractor within the framework of the above eleven tasks. These agreed-upon task descriptions are then used as the framework for planning and implementing the Apollo spacecraft reliability program. Table I summarizes the major objectives of each of the eleven reliability tasks.

The Apollo spacecraft program philosophy stresses reliability organization in-line participation and a "check-and-balance" role in the accomplishment of these tasks. This role for the reliability organization has led to important inputs into the ultimate reliability of the Apollo spacecraft.

As noted in table I, the tasks emphasize both qualitative and quantitative disciplines. The Manned Spacecraft Center has developed policies and guidelines that minimize dependence on reliability numerics alone. An example of this is the emphasis placed on crew safety, where the policy is to design subsystems on the basis that "no single failure shall mean loss of crew and no single failure shall be cause for abort." Application of this policy requires, during the design process, a vigorous failure mode and effects analysis, preparation of reliability models, and the demonstration nonstatistically of the design adequacy via well-designed and implemented test-and-failure-reporting and corrective-action programs.

TECHNIQUE FOR OBTAINING VISIBILITY IN ORGANIZATION RELIABILITY RESPONSIBILITIES

The complexities of the Apollo spacecraft program have required the development of management-type systems, agreed to and enforced by top management, for assurance that reliability tasks are accomplished by responsible organizations in an effective and timely manner. These systems depend upon relative organizational responsibilities. Typical questions requiring answers are posed, such as:

1. Who is responsible for implementation of the task?
2. Who shares task-responsibility from a participation standpoint?
3. Who monitors the execution of each task?
4. Who assures that the task is properly executed to obtain maximum reliability?

The answer to each of these questions varies from one Apollo contractor to another. For example, some contractor reliability organizations are completely responsible for test planning, whereas other contractor reliability organizations share this responsibility with engineering. A matrix was developed to aid in assigning responsibilities (table II). It should be pointed out that the responsibility assignments listed are typical and vary among Apollo contractors. The preparation of a matrix similar to that shown in table II is the initial step in the development of management control systems to assist in reliability task execution and control.

Assurance Responsibility

The reliability organization has "assurance responsibilities" for all of the tasks (table II). This requires an efficient and well-organized integrated-data-collection-and-analysis scheme to cope with other sections of the organization which are responsible for separate but functionally interrelated hardware.

Participation Responsibility

Again, as was mentioned earlier, the emphasis in the Apollo spacecraft program is to utilize the reliability organization in all in-line design and testing functions, and at the same time to carefully avoid pre-empting specific responsibilities of other organizations. This delicate balance is typically depicted in the "participation role" shown in table II.

To further amplify the "participation role" indicated for the reliability organization, reference is made to table I. Typically, the reliability organization participates in the preparation of design specifications, hardware logic diagrams, failure-mode-and-effects analysis, design reviews, failure reporting and corrective action, and test planning and monitoring. This participation is considered essential in achieving the desired check-and-balance type of reliability program.

Implementation Responsibility

The "implementation role" relative to Apollo contractor reliability organizations has typically been restricted to specialist roles, such as parts and materials, or to integration-type tasks, such as the failure reporting and corrective action area with respect to system design and maintenance of closeout actions. Another example of an integration-type role is in the assignment of reliability flight end-item project engineers whose responsibility is to ensure attention to individual flight end-items by responsible organizational elements, including the reliability organization.

Monitoring Responsibility

The "monitoring role" is typically restricted to those tasks where the expeditious use of resources requires a less-than-full-time role, such as in the selective monitoring of tests by the reliability organization.

RELIABILITY TASK PRODUCTS AND MILESTONE DERIVATION

Table III lists reliability tasks, typical outputs or products, and related milestones. These outputs must support the successful accomplishment of the program milestones if the reliability program is to have impact.

Table IV depicts these milestones for a typical R and D program. The number of reliability milestones and their interrelationships have led certain of the Apollo contractors to employ management control systems, such as program evaluation review techniques (PERT), to assist in the reliability scheduling activity.

Again, as was mentioned earlier, these milestones cannot be successfully accomplished without continuous interface with other responsible organizational elements. For this reason, in the Apollo spacecraft reliability program, strong emphasis is placed on the data collection, analysis, and reporting scheme. The intent is to accomplish the objective of taking into consideration all relevant information to maximize successful decision-making.

The complexities of the Apollo spacecraft development program have led to the requirement of key NASA/Contractor review points. A discussion of these review points is beyond the scope of this paper; however, they typically include evaluations at key design, test, and vehicle flight readiness points in the program. In addition to the design policies indicated earlier, first-article reliability emphasis is enhanced by enforcing the NASA-Apollo spacecraft policy of not committing spacecraft to flight with unresolved failures or problems.

RELIABILITY MANNING

The agreement on manning levels for reliability program implementation can well be a subject for heated debate and negotiation between the customer and the contractor. Several important ground rules that assist in minimizing disputes were used in the Apollo spacecraft reliability program budget determination:

1. Reliability responsibilities delineated for organizations other than the reliability organization are not included in the reliability budget.

2. The reliability organization is budgeted on the basis of their specific responsibilities.

3. Reliability milestones are used to justify manning levels over the program span.

Manning Ratios

Using the above ground rules, manning estimates with a firm basis are then easily prepared. Apollo spacecraft program experience has shown that the ratio of reliability organization manning to total engineering manning ranges from 3 to 5 percent. The specific values for a given Apollo contractor's reliability organization is very strongly influenced by his responsibilities.

Typical reliability task manning values have been observed in the Apollo spacecraft program, as shown in table V. The major manpower allocations are to the reliability program management; reliability apportionment, prediction, and assessment; failure mode and effects analysis; failure reporting and corrective action; and test planning and monitoring tasks.

Reliability Organization and Skills

Although a detailed discussion of reliability skills and organization is beyond the scope of this paper, several important observations have been noted during the conduct of the Apollo spacecraft program:

1. Prime consideration was given to encourage the structure of the reliability organization to preclude personnel specialization to analytical or test activities alone. Specialization of this type usually requires more manpower, added communications problems, and an organization ill-equipped to make efficient shifts with program development.

2. Consideration was given to encourage the reliability organization to insure maximum flexibility in consonance with program phasing. For example, the organization required for the analytical phase of the program requires significant change when the program moves into the hardware, testing, and operational phases.

The acquisition of key technical skills for use in the Apollo reliability organizations has proven difficult due to competitive needs by other implementing parts of the contractor's organization.

RELIABILITY MANAGEMENT CONTROL SYSTEMS

The need for a closed-loop management control system to assure timely and efficient implementation of reliability tasks cannot be overemphasized. Reliability tasks, if effectively implemented, require closed-loop procedures as, historically, failure reporting and corrective action systems are designed to insure that every failure have a specific corrective action.

The same philosophy can be applied equally to other tasks, such as failure mode and effects analysis. In this instance every potential failure mode requires a closed-loop corrective-action response, such as design changes, tests, quality control procedures, or a combination of all three corrective actions. Success trends can be used, such as: (1) number of crew safety single-point potential failure modes, (2) number of mission success single-point potential failure modes, and (3) number of failure modes requiring additional quality contols. Carrying this example further, positive management procedures are then designed to assure that the failure mode and effects analysis is used to: (1) assist in proper disposition of hardware failures, (2) prepare the test program, (3) prepare reliability predictions, (4) prepare maintainability analyses, and (5) participate in design reviews.

Key Management Control Elements

The management procedures described above, although relatively simple, are extremely important to good reliability program control, and should take cognizance of the following four key elements:

1. Relative organizational relationships (see table II)
2. Data collection and analysis requirements
3. Closeout action requirements (closed-loop requirements)
4. Trend indicators.

For example, these procedures can readily be applied to failure reporting and corrective action where the organizational responsibilities are defined (table II), the data collection requirement is fulfilled through procedures requiring in-line test or quality control functions to report failures, the failure analysis and closeout action is fulfilled by responsible organizations, and indicators, such as the number of open and total failures by age and by subsystem, are used.

Typical Management Control Subsystems

Table VI summarizes typical management control system needs for reliability program control, based on the four elements discussed above. It is important to note that these management systems interrelate with one another, and must be considered during their design.

Application of Closed-Loop Management Procedures

The application of closed-loop reliability management procedures varies with specific contractors; however, a considerable number of successful procedures have been developed and used in the Apollo spacecraft program.

STATUS OF APOLLO SPACECRAFT RELIABILITY PROGRAM

The previous sections of the paper briefly outlined the need for reliability task definition, program control, and a balanced reliability program. A natural question to ask is, "How has this approach worked on the Apollo spacecraft program?" In general, the approach has been successfully used. The following is a brief discussion of some of the implementation problems.

Derivation of Reliability Tasks and Organizational Interfaces

In general, all of the Apollo spacecraft contractors have derived applicable versions of the reliability tasks. No real problems have arisen that detailed discussions between customer and contractor did not eliminate. The aspect of scheduling outputs has, to the reliability organization, had a tremendous benefit in: (1) creating an awareness of the program needs on a timely basis, (2) acting as a "forcing function" on other organizations relative to interface-type tasks, and (3) insuring efficient manpower deployment.

The technique for displaying organizational responsibilities has provided benefit to organizations other than reliability in assisting in their understanding of their reliability responsibilities. More effort is needed in this area. An effective reliability program cannot be implemented by a reliability organization alone.

Reliability Manning

As was stated previously, the reliability manning was justified on the basis of specific reliability organizational responsibilities. There are approximately 500 reliability personnel working on the Apollo spacecraft program at both NASA and the prime contractors. In general, problems have not been caused by insufficient manning, but in the shortage of specific skills, such as parts and materials specialists.

Reliability Task Implementation

Although the implementation of the Apollo spacecraft reliability program has had its share of the normal R and D headaches, there appears to be motivation to get the job done in a reliable manner. In comparison to other R and D programs of similar complexity, the Apollo spacecraft program will leave a fine heritage for R and D programs that follow.

CLOSING REMARKS

The previous sections of the paper have pointed out: (1) the need for task and milestone identification, (2) the need for management control systems, and (3) a recognition of problems that are a normal part of complex R and D programs.

By and large, the Apollo spacecraft reliability program has, to date, been successfully implemented and should serve in many respects as a pattern for future R and D programs to follow.

A word of advice for those working in the reliability field, quoting the late Chester Irving Bernard, "Your responsibilities are very much greater than your authority. This is the general rule for responsible people, but you may be misled by the current damaging half-truth 'there can be no responsibility without commensurate authority.'"

TABLE I.- RELIABILITY TASKS VERSUS MAJOR OBJECTIVES

Task	Major objectives
1. Reliability program management	1-1 Program control systems 1-2 Audits of subcontractors 1-3 Associate contractor support 1-4 GFP control 1-5 Reliability end-items project engineers 1-6 Reliability plans
2. Design specifications	2-1 Assure specification capable of meeting reliability requirements 2-2 Placement of numerical and other reliability requirements
3. Reliability apportionments, predictions, and assessments	3-1 Reliability numerical apportionments 3-2 Reliability numerical predictions 3-3 Reliability numerical assessments 3-4 Preparation of reliability models
4. Failure mode, effect, and criticality analysis	4-1 Failure mode and effect analysis by subsystem and end-item
5. Maintainability	5-1 Operational readiness estimates 5-2 Design provisions for fault isolation and ease of maintenance
6. Design reviews	6-1 Preparation of design review criteria 6-2 Review of subsystem and system design at timely intervals using products indicated in other reliability tasks
7. Failure reporting and corrective action	7-1 Design of failure-reporting system 7-2 Failure reporting 7-3 Failure analysis 7-4 Corrective action 7-5 Derivation of failure trends
8. Parts and materials program	8-1 Parts and materials specification 8-2 Parts and materials selection 8-3 Parts and materials handling and storage 8-4 Parts and materials qualification

TABLE I.- RELIABILITY TASKS VERSUS MAJOR OBJECTIVES - Concluded

Task	Major objectives
9. Test planning and monitoring	9-1 Test plans 9-2 Test procedures 9-3 Test implementation and monitoring 9-4 Test reports
10. Reliability indoctrination and training	10-1 Program-oriented training and motivation program
11. Reliability documentation	11-1 Reliability plan 11-2 Reliability program status reports 11-3 Failure status reports 11-4 End-item reliability assessment reports

TABLE II.- MATRIX OF RELIABILITY TASKS AND

ORGANIZATIONAL RESPONSIBILITIES

TYPICAL EXAMPLE

Task	Reliability organization				Design engineering				Logistics				Quality control			
	I	P	M	A	I	P	M	A	I	P	M	A	I	P	M	A
1. Reliability program management	X			X			X				X				X	
2. Design specifications		X		X	X					X	X			X	X	
3. Reliability apportionment, prediction and assesment	X			X		X					X				X	
4. Failure mode and effects analysis (FMEA)		X		X	X						X				X	
5. Maintainability program			X	X			X		X						X	
6. Design reviews		X		X	X					X				X		
7. Failure reporting and corrective action	X	X		X	X					X				X		
8. Parts and materials program	X			X		X				X				X		
9. Test planning and monitoring		X	X	X	X					X	X			X	X	
10. Reliability indoctrination and training	X			X		X				X				X		
11. Reliability documentation	X			X			X				X				X	

Key:

I: Implement

P: Participate

M: Monitor

A: Assess

TABLE III.- TYPICAL APOLLO SPACECRAFT RELIABILITY OUTPUTS AND MILESTONES

Task	Typical task - products	Typical milestones
1. Reliability program management	1-1 Reliability plans	1-1 Program initiation every 6 months
	1-2 Reliability audits of subcontractors	1-2 Program initiation annually
	1-3 Reliability audit procedure	1-3 Program initiation
	1-4 Development of reliability control scheduling system implementation	1-4 Program initiation as required
	1-5 Reliability end-item project engineer report	1-5 Program milestones oriented – Critical Design Reviews (CDR's), Customer Acceptance Readiness Reviews (CARR's), First Article Customer Inspection (FACI), Flight Readiness Reviews (FRR's)
	1-6 Interface control documents - associate contractors and other GFE	1-6 Program initiation as revisions are required
	1-7 Negotiations with subcontractors relative to reliability requirements	1-7 At subcontractor contract initiation
2. Design specifications	2-1 Preparation of reliability specification boilerplate for design specifications	2-1 Program initiation with revisions as required
	2-2 Placement of specific reliability requirements into design specifications	2-2 As required but prior to negotiation with applicable subcontractor
3. Reliability apportionments, predictions, and assessment	3-1 Reliability apportionments - procedure and implementation	3-1 Program initiation
	3-2 Reliability predictions-procedure and implementation	3-2 CDR's and CARR's

TABLE III.- TYPICAL APOLLO SPACECRAFT RELIABILITY OUTPUTS AND MILESTONES - Continued

Task	Typical task - products	Typical milestones
3. Reliability apportionments, predictions, and assessment (Continued)	3-3 Reliability assessment - procedure and implementation	3-3 CARR's and FRR's
	3-4 Preparation of reliability models - procedure and implementation	3-4 Program initiation as used to derive 3-1 through 3-3
	3-5 Operating time system and implementation (see also 3-3)	3-5 Operating system design completed 3 months prior to first hardware manufacturing completion
	3-6 Derivation of limited life items (see also 3-5)	3-6 At CDR's (see also 3-5)
4. Failure mode, effects, and criticality analysis (FMEA)	4-1 FMEA scheduling matrix - level 2, level 3, et cetera	4-1 Three months after program initiation
	4-2 FMEA procedure	4-2 Program initiation
	4-3 Subsystem FMEA	4-3 Design reviews, CDR's, CARR's, FRR's
	4-4 System FMEA	4-4 CDR's, CARR's, FRR's
5. Maintainability	5-1 Operational readiness program procedure	5-1 Three months after program initiation
	5-2 Operational readiness program estimates	5-2 CDR's, CARR's, and FRR's
	5-3 Maintainability design analysis	5-3 Design reviews, CDR's and CARR's
6. Design reviews	6-1 Design review procedure	6-1 Program initiation
	6-2 Subsystem design reviews (not including CDR's)	6-2 Design feasibility, design freeze, qualification test completion
7. Failure reporting and corrective action	7-1 Design of failure reporting system	7-1 Three to six months after program initiation
	7-2 Failure reporting system implementation	7-2 As required, weekly trends
8. Parts and materials program	8-1 Parts and materials control procedure	8-1 Program initiation

TABLE III.- TYPICAL APOLLO SPACECRAFT RELIABILITY OUTPUTS AND MILESTONES - Concluded

Task	Typical task - products	Typical milestones
8. Parts and materials program (concluded)	8-2 Preparation of acceptable parts and materials lists	8-2 Program initiation
	8-3 Parts and materials selection	8-3 As required
	8-4 Parts and materials qualification tests	8-4 Prior to completion of applicable higher level equipment qualification tests
9. Test planning and monitoring	9-1 Test program procedures	9-1 Three months after program initiation
	9-2 Certification test network (CTN) program definition per flight end-item	9-2 One year prior to flight end-item manufacturing completion
	9-3 Subsystem test Plans and procedures	9-3 Thirty days prior to use
	9-4 Test monitoring	9-4 At selected critical test points
	9-5 Test reports	9-5 Thirty days following test completion
10. Reliability indoctrination and training	10-1 Preparation of reliability indoctrination and training plan and course data	10-1 Six months after program initiation
	10-2 Implementation of reliability training program	10-2 Continuous
11. Reliability documentation	11-1 Preparation of reliability documentation control system	11-1 Program initiation
	11-2 Reliability plan	11-2 See 1-1
	11-3 Status reports	11-3 Quarterly intervals
	11-4 EDP failure tapes	11-4 See 7-2
	11-5 Reliability end-item reports	11-5 See 1-5

TABLE IV. - TYPICAL RELIABILITY MILESTONE (Δ) SCHEDULE[a]

Task	Time: Program Initiation Δ 1st year			Time: 2nd year		Time: 3rd year	
1. Reliability program management	1-1 Δ 1-2 1-3 1-5	1-1 Δ As required	1-1 Δ 1-2	1-1 Δ CDR Δ 1-5	1-1 Δ 1-2	1-1 Δ 1-2 CARR Δ FACI 1-5	etc. FRR Δ 1-5
2. Design specifications	Δ 2-1	2-2 Δ		As required			
3. Reliability apportionments, predictions, and assessments	Δ 3-1 3-4 3-3	Δ 3-5		CDR Δ 3-2 3-6		CARR Δ FACI 3-2	
4. Failure mode and effects analysis (FMEA)	Δ 4-2	Δ 4-1 Δ Design review (as required) 4-3		CDR Δ 4-3 4-3		CARR Δ 4-3 4-4	FRR Δ 4-3 4-4
5. Maintainability	Δ 5-1	Design review Δ (as required) 5-3		CDR Δ 5-2 5-3		CARR Δ 5-2 5-3	FRR Δ 5-2

[a]See table III for milestone identification.

TABLE IV.- TYPICAL RELIABILITY MILESTONE (Δ) SCHEDULE[a] - Concluded

	Time		
	Program initiation		
	Δ 1st year	2nd year	3rd year
6. Design reviews	Δ 6-1 6-2 Δ (as required)		
7. Failure reporting and corrective action	Δ 7-1 Δ 7-2	Weekly trends	
8. Parts and materials program	Δ 8-1 8-2 Δ (as required) 8-3 Δ As tests to be completed 8-4 Prior to applicable higher level equipment qualification		
9. Test planning and monitoring	Δ 9-1	Δ 9-2	Δ 9-3 9-4 Δ (as required) Δ (as required) 9-5
10. Reliability indoctrination and training	Δ 10-1 Δ 10-2	Continuous	
11. Reliability documentation	Δ 11-1 Δ 11-3 Quarterly		

[a]See table III for milestone identification.

TABLE V.- TYPICAL APOLLO SPACECRAFT MANPOWER

ALLOCATION PER RELIABILITY TASK

Task	Percent of total reliability budget
1. Reliability program management	18
2. Design specifications	3
3. Reliability apportionments, prediction, and assessments	21
4. Failure mode and effects analysis (FMEA)	7
5. Maintainability	1
6. Design reviews	3
7. Failure reporting and corrective action	25
8. Parts and materials program	7
9. Test planning and monitoring	12
10. Reliability indoctrination and training	1
11. Reliability documentation	2
	Total 100

TABLE VI.- MAJOR RELIABILITY MANAGEMENT-CONTROL SYSTEMS REQUIREMENTS

Task	Management control system	Organizational relationships	Data collection and analysis requirements	Closeout action requirements	Possible trend - indicators
1. Reliability program management	Reliability scheduling system	See table II	Program schedules	Milestone accomplishment	Cumulative plots (for example, number of drawings reviewed versus plan)
2. Design specification	Design specification control system	See table II	Provided from other tasks	Reliability requirements placed in specifications	Cumulative planned versus actual completion plots
3. Reliability apportionments, prediction, and assessments	Mathematical model control system	See table II	Hardware logic, mission requirements, failure rates, environmental requirements, operating time, and failures	Integrated model capable of following configuration changes	Reliability estimates by subsystem and by system
4. Failure mode and effects analysis (FMEA)	FMEA scheduling matrix	See table II	FMEA deliveries from subcontractors and in-house	All level FMEA's considering lower level FMEA's	Cumulative planned versus actual completion plots
5. Maintainability	Operational readiness system	See table II	Prelaunch hardware utilization, operating time estimates, failures, and downtime permitted	Assure mission-essential ground support equipment (GSE) capable of meeting prelaunch requirements	MTBF's compared to required operating time

TABLE VI.- MAJOR RELIABILITY MANAGEMENT-CONTROL SYSTEMS REQUIREMENTS - Continued

Task	Management control system	Organizational relationships	Data collection and analysis requirements	Closeout action requirements	Possible trend - indicators
6. Design reviews	Design review control system	See table II	Data gathered from other reliability tasks	Action item closeout resulting from design review	Cumulative plot-number of action items by criticality and subsystem
7. Failure reporting and corrective action system	Failure reporting system	See table II	a. Failure reported by in-line test, QC, or subcontractor reports b. Failures analyzed by responsible organizations	Responsible organizations responsible for closeout of failures	Failure trends - number open and total failures by age and by subsystem
8. Parts and materials program	Parts and materials control system	See table II	a. Parts submitted for approval by using organizations and subcontractors b. Parts submitted for proposed qualification test by responsible organizations c. Parts master file	a. All parts approved b. All parts qualified c. Preparation and maintenance of parts master file	Cumulative plots - parts planned for approval and actual approvals versus time; parts planned for test and actual test completions versus time

TABLE VI.- MAJOR RELIABILITY MANAGEMENT-CONTROL SYSTEMS REQUIREMENTS - Concluded

Task	Management control system	Organizational relationships	Data collection and analysis requirements	Closeout action requirements	Possible trend - indicators
9. Test planning and monitoring	Test program control system	See table II	Definition of required tests and when required	Successful test completion	Cumulative plot - planned and actual test completion versus time; test status list
10. Reliability training	Reliability training program	See table II	Based on other task needs	Course completions	Cumulative plot - number of students completing reliability courses versus time
11. Reliability documentation	Documentation control system	Reliability organization	Based on contractual documentation requirements	Meeting suspense dates	Cumulative plot - number of documents reviewed by types versus time